THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VIII.

No. XII.—DECEMBER, 1891.

ORIGINAL ARTICLES.

I.—On *Olenellus Callavei* and its Geological Relationships.

By Prof. Charles Lapworth, F.R.S.

(PLATES XIV. and XV.)

In the year 1888 I published a short paper in the pages of the Geological Magazine[1] and in "Nature,"[2] in which I gave a brief account of the discovery of the fauna of the *Olenellus* (or Lower Cambrian) zone in the Comley or Hollybush Sandstone of Shropshire. Since that date great advances have been made in our knowledge of the *Olenellus* fauna of other areas, and the *Olenellus* zone has now generally attained an established rank and systematic position in the Geological Record as the basal zone of the Cambrian system.

At the time my paper was written sufficient material had been obtained to enable me to recognize the existence of a well-marked species (*Ol. Callavei*) of the genus *Olenellus* in the Comley Sandstone series. But the form appeared to be so closely allied to the *Olenellus Bröggeri*, which had been discovered by Mr. Walcott,—the distinguished palæontologist of the United States Geological Survey—in the basement beds of the Cambrian of Newfoundland, and exhibited and named by him at the meeting of the Geological Congress in London in 1888, that, as I explained in the paper referred to, I felt that it was but just that I should await the appearance of the formal description of his species before publishing my own.

Thanks to the kindness of Mr. Walcott, his brilliant and long-expected Monograph "On the Fauna of the *Olenellus* Zone"[3] now lies before me, in which *Olenellus Bröggeri* is admirably figured and described; and although it includes a comparative diagnosis of *Olenellus Callavei*, sufficient for registration and identification, I take this my first possible opportunity of figuring and describing in full our Shropshire form, that the want of acquaintance with its minor specific characters may not delay those who may be desirous of publishing new species from the *Olenellus* zone elsewhere.

[1] Lapworth, "On the Discovery of the *Olenellus* Fauna in the Lower Cambrian Rocks of Britain," Geological Magazine, 1888, Dec. III. Vol. V. p. 485.

[2] "Nature," vol. xxix. p. 213.

[3] See next page.

The fragments figured on Plate XIV. are those which were exhibited by myself at the meeting of the Geological Congress at London in 1888, supplemented by a few others which were at the time in my possession. The majority were collected by Mr. H. Keeping (acting under my instructions with the kindly consent of Prof. T. McKenny Hughes, F.R.S.) during the previous years, and are the property of the Woodwardian Museum, Cambridge.

The restoration attempted on Plate XV. is founded essentially upon these fragments; so that palæontologists will be able to judge for themselves in what respects that restoration is justified or defective.

Olenellus (Holmia) Callavei, Lapw.

Plate XIV. Figs. 1–25. Plate XV. Fig. 26.

1888. *Olenellus Callavei*, Lapworth, Geological Magazine, Dec. III. Vol. V. p. 485.
1888. *Ibid.* Lapworth, "Nature," vol. xxix. p. 213.
1889. *Olenellus Callavei*, Walcott, American Journal of Science, vol. xxxvii. p. 391.
1891. *Olenellus* (*Holmia*) *Callavei* (Lapw.), Walcott, "Fauna of the *Olenellus* Zone," 10th Report Geol. Survey, U.S.A., pp. 640–641, p. 581, etc.

Description.—General form ovate-elliptical, about one and a half times longer than broad. Head broad, semi-circular to semi-elliptical in outline and moderately convex. Margin edged exteriorly by a broad conspicuous rounded rim or flange, and limited interiorly by a faint parallel angular ridge. Posteriorly the margin is broadened and prolonged in a strong rounded spine. The under side of the proximal margin forms a broad rounded doublure. The posterior margin of the head bears two short, stiff, spur-like "interocular" spines, which are directed backward and outward, and are continued interiorly by a faint ridge which appears to be prolonged almost to the crest of the glabella in advance of the occipital furrow.

Glabella broadly convex in elevation, and sub-clavate in outline; attaining its greatest width near the anterior extremity of the eye-lobe, and having a sharply rounded to sub-triangular frontal edge. It is furnished with three pairs of glabellar furrows (with traces of a fourth anterior pair). They occur as shallow and broad double depressions, deepest midway between the axis and the lateral margins, and almost disappearing as they cross the central parts of the glabella. Occipital furrow of the same type as the rest; but broader and deeper, and limited in part anteriorly by a slight but conspicuous ridge (the proximal extension of the "interocular" process?). Occipital ring flat and narrow laterally; rising posteriorly to a strong marginal rim, and rapidly increasing in width and height to its centre, where it insensibly graduates into a stout claw-like spine, which arches backward over the first two (?) segments of the thorax.

Eye-lobes prominent, elongate, narrow, lunate to semi-circular, situated sub-centrally with respect to the height of the glabella; arching outward from the base of the anterior lobe to a distance equal to half the width of the glabella, and backwards almost to a line with the occipital furrow. Visual surface unknown. Area

between glabella and eye-lobe flat, and separated from the glabella by an irregular undulating groove. Frontal limb narrow. Surface of free cheek slightly convex, sloping inwards to the eye-lobe, and outwards to the groove bounding the lateral margin. Thorax with 18 (?) segments. Axial lobe elevated; prominently rounded and narrowing throughout. Each axial segment is well defined. It is thickened posteriorly and laterally grooved; and it bears centrally a short and stout recurved claw-like spine, with a spreading base, and a sharp ridge-like upper surface. The terminal segments bear in addition two lateral rudimentary spurs, while the central spine is much reduced in size. Pleural lobes, flattened for the first half to two-thirds of their length; and then gracefully curving and contracting to the recurved falcate extremity. The proximal surface of each is relieved by an oblique pleural groove.

The associated pygidium is small, simple, almost semi-circular in form; with slightly converging lateral margins, straight and shortened posterior edge, distinct central elevation, and anterior groove.

The test or body-covering of both head and thorax is marked throughout by a raised fretwork of inosculating lines or ridges, the pattern of which varies in different parts.

Dimensions.—The larger fragments collected indicate a length of about six inches and a breadth of about four inches. With the exception of *Olenellus* (*Holmia*) *Bröggeri*, Walcott, this form is the largest species of the genus yet discovered.

Comparisons.—*Olenellus Callavei*, as I have already more than once pointed out,[1] is most intimately allied to *Olenellus Kjerulfi*, Linnarsson, from the Lower Cambrian of Norway, and *Olenellus Bröggeri*, Walcott, from the basal beds of the Cambrian of Newfoundland. These three species appear to me to constitute a special subgeneric (?) group, intermediate between *Olenellus*, Hall (including *Mesonacis*, Walcott, and *Olenoides*, Meek). They all possess the remarkable "interocular" processes and conspicuous dorsal spines of the latter, but differ in the absence of the facial suture. They agree with *Olenellus* (including *Mesonacis*) in the general form of the head and of the glabella, and in the peculiar ornamentation of the test; but differ in the absence of the great median or terminal spine. From both groups they are strikingly distinguished by the great development of the occipital process. In allusion to this common characteristic feature, I suggested for the group the title of *Cephalacanthus*;[2] but, as Mr. Walcott has pointed out, this term must give way to *Holmia*, the subgeneric title published by Mr. Matthew[3] in June, 1890, for *Olenellus* (*Holmia*) *Kjerulfi*, Linnrs., the first discovered species of the group.

Olenellus Callavei not only agrees with *Ol. Kjerulfi* in its general characters, but in the conspicuous development of the interocular spines, in the existence of a faint ridge sweeping back from the

[1] Geol. Mag. etc., *loc. cit. supra*. Fauna *Olenellus* Zone, pp. 640–641.
[2] Geol. Mag. 1888. p. 641.
[3] Matthew, Trans. Roy. Soc. Canada, 1890, p. 160.

spine almost to the axis of the glabella just in advance of the neck furrow; in the double character of the lobes and furrows of the glabella itself, and in the form and position of the eyes. It differs from *O. Kjerulfi* in its larger size, and more compact habit; in the rapid contraction of the glabella towards the front, in the much greater development of the occipital spine, and in the falcate character of the terminal parts of the pleuræ.

O. Callavei agrees, on the other hand, with *Ol. Bröggeri* in all those features which distinguish the former from *O. Kjerulfi*; and differs from it in all those characters which are common to the English and Norwegian forms. In addition, a minor distinction is constituted by the much greater extension of the genal and interocular processes in *O. Callavei* than in *O. Bröggeri*, and a much lesser extension of the great occipital spine.

The form is dedicated to my friend Mr. Charles Callaway, D.Sc., F.G.S., who was the first to detect organic remains in the Comley Sandstone, and the first to demonstrate the presence of true Cambrian fossils in Shropshire generally; and whose original and sagacious inference as to the probable pre-Cambrian age of the unconformably underlying rocks the discovery of *Olenellus* places beyond much dispute.

In addition to the fragments upon which the foregoing description has been mainly drawn up, a few figures (Figs. 24 and 25) are given on Plate XIV. of younger examples of the species, in which the same characteristic features will be recognized.

Olenellus Callavei occurs in a highly calcareous bed of bright purplish-red calcareous sandstone, or sandy limestone, near the base of the Comley Sandstone (Hollybush) series of Central Shropshire. The figured specimens were all procured from a single locality—the Comley Quarry—at the foot of the hill of Little Caradoc, near Church Stretton. In this district the *Olenellus*-bearing sandstone *passes down* into olive-green felspathic flags, grits, and concretionary shales, and the base of the entire Comley Sandstone series is formed of the well-known Caradoc or Wrekin Quartzite, which reposes unconformably upon the Volcanic Uriconian Group of Callaway. The *Olenellus*-bearing beds are *overlain* at once by conglomerates, and gritty and quartzose strata, containing abundant fragments of igneous rocks, concretions of carbonate of copper, calcareous bands, and limy nodules; and these in turn pass up into flaggy shales and quartzose grits, forming the highest visible parts of the Comley series.

Olenellus Callavei appears to be strictly confined to that part of the Comley series which lies below the conglomerate bands mentioned above; and its associates include *Kutorgina cingulata*, *Linnarssonia sagittalis*, *Hyolithellus* (compare *H. micans*, Walcott) and *Ellipto-cephalus*, sp.

The overlying conglomerates and limestones are distinguished by the presence of a large species of *Paradoxides* (*P. Groomii*[1] sp. nov.), together with forms of *Ptychoparia*, *Obolella*, *Protospongia*, etc.

[1] *Paradoxides Groomii*, sp. nov. In general form and size intermediate between

The generic position of the two characteristic forms of the Lower and Upper Divisions of the Comley Series being thus settled, the descriptions of the less important associated forms may conveniently be deferred to a more favourable occasion.

We possess in the foregoing facts sufficient palæontological evidence to establish the Lower Cambrian age of that part of the Comley series which contains the genus *Olenellus*; and we have now obtained stratigraphical and palæontological proof that it is succeeded at once by the so-called Middle Cambrian or *Paradoxidian*. Further, as Dr. Callaway[1] originally pointed out some years ago, the Hollybush (or Comley Sandstone) series is followed in turn by the Shineton Shales, which contain locally a fauna of highest Cambrian age. In these Central Shropshire rocks, therefore, the Comley and Shineton Groups, which constitute an integral part in this district of Murchison's original *Lower Silurian*, and have a collective thickness of perhaps less than 3000 feet, we have apparently a condensed epitome of the entire Cambrian system as at present generally defined.

Here, as elsewhere, we find the Cambrian divisible into three sections — an Upper Cambrian above, marked by the presence of the genus *Olenus* (Olenidian); a Middle Cambrian group with *Paradoxides* (Menevian or Paradoxidian); and finally a Lower Cambrian (*Olenellus* zone) or basal group (possibly of somewhat different systematic importance), distinguished by the presence of *Olenellus*. No one has yet, so far as I know, suggested any general title for the basal division of the Cambrian. Recollecting, however, that the very first discovered species of the genus *Olenellus* was named and figured[2] by the American geologist, Dr. Emmons, as early as 1846 from the rocks of his Taconic or Taconian system; and was claimed by him as early as 1853[3] as coming from strata older than any of the fossil-bearing Silurian (including the Primordial zone) then discovered; while even at the present day the genus holds its own as marking a distinct and identifiable life-zone in the strata of Emmons' typical Taconic area; it would be very convenient if geologists and palæontologists generally would agree in calling it the Taconian.

In my short paper already referred to, "On the Discovery of the *Olenellus* Zone in Britain," I drew a few provisional inferences, novel at that time, but thrown out then as "constituting a provisional working hypothesis, of service mainly as a guide and

Par. Harlani (Green) and *Par. Davidis* (Salter). Length 8 to 9 inches, breadth 5½. *Head* semi-circular, with pointed genal spines from two to three inches in length. *Glabella* prominent, clavate, more than half its length being occupied by the broadly rounded and smooth frontal lobe. *Hypostoma* of the type of that of *Par. Bohemicus* (Boeck). *Pleuræ* (no ?) falcate, and sharply pointed. Pygidium a raised disc with central tubercle; embraced laterally by long, sabre-like, distally-diverging spines. *Localities.* Neves Castle (Lapw., 1889) and Comley (Groom, 1890). Named after T. Theo. Groom, Esq., B.Sc., who first collected fragments sufficient for description.

[1] C. Callaway, "Upper Cambrian Rocks in South Shropshire," Q.J.G.S. 1877, p. 652, etc.

[2] As *Elliptocephala asaphoides*, Emmons, Taconic System, 1846, p. 213, figs. 1, 2, 3.

[3] Emmons' American Geology, 1855, pt. ii. pp. 6 and 7, etc.

stimulus to future discussion, investigation, discovery and correction." It is somewhat instructive to note how—taking the publication of these provisional inferences as our starting point—geological knowledge and opinion in this department has advanced in the interval. These theoretical conclusions were three in number, and for the sake of comparison—the contrasts between them (as paraphrased from their original crude form), and their present aspect (in so far as can be deduced from the actual state of geological opinion),—may very briefly be summarized as follows :—

(*a*) The presence of *Olenellus* in these Shropshire strata appears to fix the pre-Cambrian age of the Uriconian Series of Dr. Callaway, and to render the pre-Cambrian age of his Longmyndian a matter of fair probability.

Since 1888, Professor Blake, who has of late years added very much of great value to our knowledge of the Cambrian and pre-Cambrian rocks, unhesitatingly assigns the lower zones of the Longmynd Series of Callaway to his own Monian, or pre-Cambrian.[1] Sir A. Geikie, after studying the *Olenellus*-zone and the overlying and underlying rocks in the field, has frankly expressed his view that the Uriconian may be of pre-Cambrian age.[2] Finally, the fact brought forward in the present paper—namely that representatives of all three divisions of the true Cambrian, as at present acknowledged, are actually known to occur in Central Shropshire, being mapped as constituting an integral part of Murchison's original Lower Silurian,—renders it very unlikely that the Longmyndian (the original pre-Silurian or Cambrian of Murchison and the other great stratigraphists who immediately followed him) can be anything else than pre-Cambrian.

(*b*) The so-called Upper Cambrian of the Malverns, Central England and N.W. Scotland may be in reality a greatly attenuated representative of the entire Cambrian system; part of an originally fairly continuous Cambrian once extending from Lapland through Britain and Europe to Sardinia—and the Sardinian and Durness formations may both range down to the base of the Cambrian.

The recent brilliant discovery of *Olenellus* by the officers of the Geological Survey of Scotland,[3] in the Fucoid and Salterella zone, in the lower parts of the Durness-Eriboll Series, establishes the correctness of this suggestion for the N.W. Highlands. The detection of *Paradoxides Groomii* in the supra *Olenellus*—infra *Olenidian*—zones of Central Shropshire, as described in the preceding pages of the present paper,[4] appears to settle the matter equally satisfactorily as regards Southern Britain :—

(*c*) If so the Torridon Sandstone of North West Scotland would possibly go with the Longmyndian into the pre-Cambrian, the Schists of St. Lo in France, and the rocks of corresponding antiquity elsewhere.

Here, again, this provisional conclusion has been extended and left far behind by later research and opinion. As already pointed out by Sir A. Geikie,[5] the discovery of *Olenellus* in the Durness-Eriboll

[1] J. F. Blake, On the Monian and Basal-Cambrian Rocks of Shropshire, Q.J.G.S. 1890, p. 386, *et. seq.*

[2] Sir A. Geikie, Anniversary Address, Q.J.G.S. 1891, pp. 86–90.

[3] Sir A. Geikie, GEOL. MAG. 1891, p. 449.

[4] See *ante* p. 532.

[5] *Ibid.* p. 449.

Series fixes the pre-Cambrian age of the Torridon Sandstone. Again, Dr. Katzer[1] has shown that the strata of the Bohemian Urgeberge (the Cambrian[2] of Barrande and Murchison—Etages A. and B.) lie (at least locally), unconformably below the rocks of the true Cambrian or Primordial zone (a conclusion recently confirmed by Dr. Wentzel[3]) and must, therefore, be now classed as pre-Cambrian or Archæan. In precisely the same way in two recent and most valuable memoirs by M. Bergeron and M. Bigot we are presented in one area (N.W. France) with clear physical proofs,[4] and in another (Languedoc) with actual palæontological evidence,[5] that the condensed Cambrian of Central Britain is apparently prolonged through France from the Channel Isles to the Montagne Noire; and as a consequence the underlying (often unconformable) schists of St. Lo, etc.—*i.e.* the Cambrian of Dalimier, Dufrenoy and Murchison—may now be regarded as of Archæan or pre-Cambrian age.

Thus while we have still very much to learn respecting the fossils, the component members, and the local development of the ancient Palæozoic strata, and while we must admit that many of our present inferences and conclusions lie open to improvement and correction by future investigation and discovery—the students of these old rocks (however much they may conscientiously differ in the provisional nomenclature in which they clothe their facts) have now all more or less attained to the conviction that we are at last reaching a satisfactory homotaxial base to the Palæozoic rock-series. We now see that the Lower Palæozoic cycle of formations (the Protozoic or Protogean) or the Silurian of Murchison's '*Siluria*' and Barrande's '*Système*' has proved itself to be a geological cycle of the first order. We agree, in principle, that it is made up (like each of the succeeding great cycles), of three sub-equal groups[6] or systems—an Upper system (the *Silurian* proper, or *Salopian*) a Middle system (the *Ordovician*) and a Lower system (the *Cambrian*). This lower system, like each of the two systems above it, has now shown itself divisible in its turn into three sections—an Upper Cambrian (*Olenidian*), a Middle Cambrian (*Paradoxidian*) and a Lower Cambrian (*Taconian*).

Underneath this Cambrian lie sometimes conformably, sometimes unconformably, the strata of the mysterious cycles of the Pre-Cambrian (or Archæan). Of these, certainly the rocks of the unaltered divisions (the Eozoic or Eogean cycle) are now so well circumscribed geographically that there appears little to hinder their detailed study and investigation by an extension and development

[1] Dr. Fr. Katzer, Das ältere Palæozoicum in Mittel Böhmen, Prague, 1888, pp. 5, 7.

[2] Siluria, 4th edition, p. 273.

[3] Dr. Josef Wentzel, Die Beziehungen der Barrandischen Etagen C, D, E zum Britischen Silur., Jahrbuch d. k. k Reichsanstalt, Wien, 1891, p. 119.

[4] A. Bigot, L'Archéen et le Cambrien du Massif Breton, Cherbourg, 1890, pp. 25, 73, etc.

[5] J. Bergeron, Etude géologique du Massif ancien du Plateau Central, Paris, 1889, p. 78, pl. ii.

[6] The *Silurien supérieur*, *Silurien moyen*, and *Silurien inférieur* respectively, of the younger French geologists.

of the same rules which have been employed in satisfactorily determining the order and the characteristic organic remains of the more recent systems. Surely it is not too much to hope that the day is fast approaching when these Eozoic formations will be reduced to their natural order as fossil-bearing systems, comparable in all respects (except in the greater paucity of their organic remains) with the Post-Archæan systems which at present form the accepted members of our great geological scale.

EXPLANATION OF PLATE XIV.

FIG. 1. *Olenellus Callavei*. Glabella in relief, showing the characteristic shape, the lobes and furrows, and the broken base of the occipital spine.
FIG. 2. ——— ——— Do. Side elevations.
FIG. 3. ——— ——— Occipital lobe with base of central process. Posterior aspect.
FIG. 4. ——— ——— Fragment of hinder part of glabella, etc., from above, showing size and length of a broken occipital spine.
FIG. 5. ——— ——— Do. Side elevation.
FIG. 6. ——— ——— Fragment of part of head, showing marginal and interior ridges.
FIG. 7. ——— ——— Terminal part of free cheek with marginal ridge, and genal and "interocular" spines.
FIG. 8. ——— ——— Do. Another and smaller example.
FIG. 9. ——— ——— Eye lobe.
FIG. 10. ——— ——— Do. Smaller example.
FIG. 11. ——— ——— One of the anterior segments of the axis, showing the form and position of the median spine.
FIG. 12. ——— ——— Do. From central parts of axis.
FIG. 13, 14. ——— ——— Do. Profile views.
FIG. 15. ——— ——— Segment of axis near posterior end.
FIG. 16. ——— ——— Sub-terminal (?) segment of axis, showing central and lateral tubercles.
FIG. 17. ——— ——— Pygidium.
FIG. 18. ——— ——— One of the proximal pleuræ, showing general form, pleural groove, and falcate extremity.
FIG. 19, 20. ——— ——— Pleuræ from near posterior end of thorax.
FIG. 21. ——— ——— Superficial ornamentation of test. (Magnified.)
FIG. 22. ——— ——— Ditto. (Magnified.)
FIG. 23. ——— ——— Doublure for attachment of hypostoma.
FIG. 24. Young form of *O. Callavei*, showing general form and characters of the glabella, eyes, frontal margin, etc.
FIG. 25. Do. Another example.

(All the fragments figured, except Figs. 21 and 22, are of the natural size.)
Figs. 18, 19, 20, 24, are from my own Collection, the remainder are in the Collection of the Woodwardian Museum, Cambridge.

PLATE XV.

FIG. 26. *Olenellus Callavei*, Lapw. Theoretical restoration, natural size.

II.—PETROLOGICAL NOTES ON SOME LAKE DISTRICT ROCKS.

By W. MAYNARD HUTCHINGS, Esq.

DURING the last three years I have at various times collected and studied rocks from the Lake District. Some of them are, I think, of sufficient interest to render them worth describing. It is my opinion that a great deal of very interesting petrological work still remains to be done among these rocks, and that when they are

more studied in detail they will be found to present more diversity of type than is usually supposed.

I will first note the occurrence of a variety of rock not previously recorded in this district. It is a quartz-andesite, or dacite. It is exposed on the ridge between Greenburn and Wytheburn, not very far from Dunmail Raise, and near to a new wire-fence which bounds, I believe, the property of the Manchester Waterworks. It is a dark-coloured rock, on a newly-fractured surface of which are seen numerous light spots of porphyritic felspars, and some of calcite, with many grains of quartz, some of good size. It was the grains of quartz which instantly attracted my attention to this rock when a bit was chipped off it in passing the exposed crag.

Under the microscope these grains of quartz are seen to be corroded and eaten out into "bays and gulfs," and their nature as true constituents of the rock, and not extraneous fragments, is vouched for by their enclosures of ground-mass. None of them show definite crystalline form. In addition to the larger porphyritic grains, some very small ones are seen among the ground-mass, but not abundantly.

The many porphyritic felspars are fairly well preserved. They are plagioclase, mostly well twinned, sometimes on both albite and pericline systems. So far as may be inferred from the extiction-angles of symmetrically-extinguishing twins, the chief felspar present appears to be oligoclase.

The porphyritic ferro-magnesian constituent appears to have been mainly, if not wholly, biotite, which was abundant. The outlines and cleavages of the numerous large individuals are still quite preserved, but great alteration has taken place into chlorite, epidote, and indeterminable matter, probably partly carbonates and ferric oxides.

I have not met with any other andesite in the district in which biotite can be recognized as present, or formerly present, nor am I aware of any such rock having been recorded. My impression is that biotite-andesite was very sparingly represented, though of course it is possible that the chlorite, so abundant in some cases, may partly represent former biotite; but in that case we should expect to sometimes see recognizable pseudomorphs, as one so frequently does in these rocks after augite.

The ground-mass of this quartz-andesite consists of a network of small felspar-laths, intermixed with, and at places more or less obscured by, grains of chlorite, epidote, sphene, calcite, and other matter, as is usual in all these rocks. In the greater portion of it the felspars are very distinct and fresh, and allow of optical measurements. They are largely untwinned, the rest being binary twins. Extinctions are either quite parallel or at very low angles. We may conclude that there is oligoclase, and most likely some orthoclase present. So far as can now be made out, very little, if any, glass was present in the original rock. There are many good-sized crystals of apatite, and zircons are much more numerous than in the usual local andesites. The sp. g. of the hand-specimen

brought away is 2·74, and the silica-percentage is 60·45. Roth gives as the outside figures for silica recorded for dacites, 68·18 per cent., and 55·91 per cent. respectively, the latter being from an altered rock. It is not likely that the figure obtained by me for this Lake District dacite quite represents the *original* percentage, which, judging by the alterations, was probably a little higher, though certainly not nearly high enough to place the rock among the rhyolitic andesites. We have here, then, a well-characterized biotite-dacite, and it is likely that this or a similar rock will be found exposed at other points besides the one indicated.

Another rock occurring above Easedale Tarn, Grasmere, on the side towards Langdale, is a conspicuous representative of the other extreme of the series of Lake District rocks. It is a dolerite, a good deal more basic than any described by Mr. Ward, and differing in other ways from any hitherto recorded in the district. It is a very dark-coloured rock, easily recognized with a pocket-lens as a rather coarse-grained dolerite, without any porphyritic structure. Microscopic examination shows it to be made up of augite and plagioclase-felspar, with usual alteration-products. Augite is abundant, and much of it is still quite fresh. It existed originally, apparently, wholly as irregular grains, mostly of good size. The rock has undergone considerable crushing and shearing, and many augite-grains are cracked in several places, the cracks being cemented with chlorite. In some cases large grains have been completely shattered into small fragments, now lying among chlorite and calcite, due to subsequent infiltration. Here and there augite is fringed with secondary hornblende, but chlorite is the more usual alteration-product.

The felspar is in the form of relatively broad laths, tabular sections, and many irregular grains; it has been a good deal affected mechanically, like the augite, but is very fresh otherwise. There is no ophitic structure and no trace of ground-mass of any description. The rock is distinctly a holocrystalline, non-porphyritic dolerite, verging towards *granitoid* structure. The sp. g. is 2·95, and the percentage of silica is 45·65.

Another totally different type of basic rock examined is from near the summit of Scarf Gap Pass. Mr. Ward mentions a bed of basic lava on the east side of the pass, and gives description and figure of it. I do not know whether this is the same rock, and his figure is of very little use in deciding, while some points in his description do not agree with the occurrence here noticed.

It is a vesicular rock, the vesicles being now infilled with chlorite and other alteration-products. It has comparatively few porphyritic felspars, all very much altered. There is abundant porphyritic augite in good-sized crystals and grains, much of which is still perfectly fresh, though much fractured in some cases. The ground-mass consists of very small felspar-laths, perfectly fresh, nearly all binary twins. They are mainly if not wholly labradorite. There is the usual abundance of alteration-products throughout the ground-mass, but a good deal of augite in small grains is still dis-

tinguishable. There appears to have been a good deal of interstitial glass originally, but it is now devitrified, and obscured by alteration. The sp. g. is 2·82 and the silica-percentage 51·35. This rock, then, corresponds to a porphyritic augite-dolerite, or probably, more correctly, basalt.

Turning to the andesites, there is a type of them abundantly represented at one part of the district, and apparently recurring at several other points, which is very interesting and differs in several ways from the usual varieties as described by Mr. Ward, or as summarized by Sir A. Geikie (Presidential Address to Geol. Soc. 1891). It consists of rocks of mostly a grey-green or grey-blue colour,—a colour not easy to exactly describe,—with resinous lustre and extremely splintery fracture. On a newly-broken surface small dark spots are seen, but hardly ever any sign of a felspar, and when seen these are very small. These particular rocks are exposed largely at Harter Fell, Mardale, making the main part of the cliff facing towards Haweswater; on the ascent from Nan Bield Pass on to High Street; and in cliffs on the right side of Kentmere Valley, some distance below the reservoir.

A series of sections prepared from specimens taken at all three of the above localities shows that the rock is essentially the same in nature at all of them. There are numerous felspar-crystals, sharp in outline, though inwardly much altered, porphyritic in a ground-mass which originally varied from a wholly glassy base to an intimate mixture of glass and exceedingly minute felspar-microlites. There are chlorite-pseudomorphs after augite, distinct in form, as well as indefinite patches and streaks of chlorite. The entire ground-mass is permeated by chlorite in minute flakelets, with small granules of epidote, calcite, and other matter.

Sections from the summit of Harter Fell, close to the double cairn, show a good deal of perfectly fresh augite as well as many pseudomorphs. The ground-mass here consists nearly wholly of devitrified glass; a dimly-polarizing, speckly, felsitic mass with scarcely any felspar microlites at all. Sections from Kentmere, again, have a ground-mass of the most typical "hyalopilitic" nature, wherein the same devitrified glass is quite full of tiny laths and needles of felspar, showing well-developed flow-structure round the porphyritic felspar-crystals. The largest and most clearly-developed of these felspar-needles are close around $\frac{1}{1000}$th inch in length and extinguish quite parallel. The average size is very much less.

There is no doubt that, though varying more or less in detail from place to place, and even within very short distances, we have here an altered augite-andesite of a much more vitreous nature than the dominant type of lavas of the Lake District. A characteristic specimen from above Nan Bield has the sp. g. 2·65 and a silica-percentage of 57·55.[1]

[1] Mr. Ward refers to rocks of a grey-blue colour, very compact, which are outwardly not unlike those above described. The closest resemblance is in a lava from near Lodore Hotel, which is singled out by him on account of its non-porphyritic nature and the smallness of its felspar-needles. He gives the average

Rocks closely similar to the above, macroscopically and microscopically, are exposed on both sides of Easedale Tarn, Grasmere. One specimen, from the right side of the Tarn, is very much altered and impregnated with calcite and other secondary matter, reducing its silica-percentage to 52·45. Its ground-mass appears to have been wholly vitreous, and porphyritic felspars, etc., are very scarce. Specimens from the opposite side of the Tarn are again full of minute felspar-needles, are less altered (free from calcite), and have a silica-percentage of 60·75; but here also the porphyritic constituents are much less abundant than at Harter Fell, etc.

From these vitreous and minutely "hyalopilitic" varieties, we may see all gradations of development of crystals in the ground-mass, up to the more usual, much coarser-grained andesites, as we mainly have them in Mr. Ward's descriptions.

An interesting example is exposed in a small disused quarry by the side of the road from Seatoller to Seathwaite. The rock is grey tinged with green, showing dark spots of chlorite, but no felspars to eye or lens. It is very fissile, splitting into tolerably thin plates, and approaches more nearly to a slaty cleavage than any other lava known to me in the district; though I am told there are cases of lavas which are sufficiently cleaved to be worked for roofing-slates. The ground-mass-felspars in sections from this quarry are still small, but larger than in the rocks just described, ranging up to $\frac{1}{300}$ of an inch as maximum. Porphyritic felspars are greatly altered, being almost wholly replaced by calcite, and deformed by pressure and shearing; but the pseudomorphs after augite are mostly but little damaged, and show more numerous recognizable forms than in any other slides I have. The ground-mass is completely permeated by infiltrated calcite, of which there is so much present altogether that the silica-percentage of the rock now only reaches 51·6, though originally it must have been fully as high as in the average local andesites, if not higher.

The numerous lavas on Dale Head, High Scawdell, and Seatoller Fell, present an interesting variety, as we find here not only the more normal Lake District andesites, but also types which seem to lie between these and the basic rocks, and to require such terms as doleritic (better basaltic) andesite, or andesitic dolerite (better basalt), to describe them;—that is, if we adhere to the more usual custom of distinguishing between andesites, and dolerites or basalts, as extremes of a series. Of course they all pass imperceptibly into one another, and there are petrologists who call the whole series andesites, as does Professor Cole in his system of classification ("Aids in Practical Geology"), simply distinguishing them at the ends of the line as "trachytic andesites" and "basaltic andesites" Rock-classification, in the present state of the subject, is very much

length of these as $\frac{1}{725}$th of an inch. They are, therefore, very much larger than in the rocks referred to by me, and from his description the Lodore lava was evidently very much less vitreous than these. It resembles, as Mr. Teall points out, the ground-mass of the average andesites of the district; a ground-mass in which the felspars are above the average sizes of typical andesites elsewhere.

a matter of individual taste, so many are the systems offered to us. For my own part I think a very much clearer idea of the rocks is conveyed by the more usual method of separate grouping of andesites and basalts (using the name *dolerite* exclusively for non-vitreous rocks); as is exemplified in the classification given by Dr. Hatch ("Introduction to the Study of Petrology"). Various stages of the passage from one to the other extreme may then be clearly indicated by the use of the adjectives *basaltic* and *andesitic* respectively, according to whether we wish to specify an andesite which is tending towards a basalt, or a basalt which is tending towards an andesite.[1]

While on this subject, it is difficult to see why we should retain in use the word "porphyrite" for altered andesites like those of the Lake District. The supposed differences between rocks of different geological age being no longer admitted among English petrologists, and bound to vanish also in Germany sooner or later, why retain any of the names which are connected with the obsolete system of classification, and which appear wholly superfluous when once this is discarded? As some writer has said, I think, in effect, why should we have a separate name for an old and altered rock, any more than we have a separate name for a *man* because his hair is grey and his teeth no longer well preserved? Such names only burden the memory, obscure ideas, and open the way for confusion, because they are so liable to be used in different senses by different writers. It is better, and specially so for younger students, to use two words (or a whole sentence if necessary!), and to convey a clear and unmistakeable idea by their means, than to use one word which itself needs a definition attached to it, and very likely has several different ones. Why should not such words as porphyrite, melaphyre, propylite, and very many more, disappear into the lumber-heap? They are only a stumbling-block to beginners, and an unnecessary addition to a nomenclature too much burdened with dreadful names in any case.

The regular types of andesites of the district have in their ground-mass a felspar which shows very small angles of extinction, and sometimes extinguishes parallel.

It seems tolerably safe to assume that oligoclase largely prevails, and it is very probable that orthoclase is also frequently present. But there are also rocks in which these optical tests show a felspar allied to labradorite to be present in the ground-mass. Labradorite does not appear to be usually recorded as existing in the ground-mass of normally acid andesites. In some of the lavas on Dale Head, etc., examples of it may be seen, lavas which are very full of porphyritic felspars and are unquestionably *andesites*.

[1] Mr. Teall uses the term "andesitic dolerite" on several occasions, pointing out that some authors would simply call such rocks augite-andesites; and he adds the very sensible reminder that "it is a matter of indifference what we call them, provided we recognize their true characters and relations" (British Petrography, pp. 194, 195).

A rock from Seatoller Fell is of some interest. It is a very compact, dark rock, quite free from vesicles. Its numerous porphyritic felspars are all much altered, though still perfect in outline and relationship to the ground-mass. There are no definitely recognizable larger pseudomorphs of chlorite after augite, though good large patches of chlorite are present. The ground-mass consists of perfectly fresh felspar-laths of a rather larger size than usual, all twinned, and showing by many extinction measurements that labradorite is dominant. These felspars lie in among a yellow-brown, dimly-polarizing, partially devitrified glassy base, full of minute dark dusty matter. The amount of this base is considerable. In among the felspars and glass are a large number of good-sized irregular grains of very pale-green hornblende, which is clearly secondary after former augite. In many cases the felspars penetrate the hornblende in a manner showing that a certain amount of ophitic structure was present, but more usually the grains lie wedged in the angles formed by the felspars. There are also numerous bits of chlorite occurring in exactly the same manner as the hornblende. Originally the rock must have contained a considerable amount of augite in this form, but none of it is now seen unaltered. There is abundance of finely disseminated chlorite and grains of epidote, some of which appears to represent a smaller generation of augite in the ground-mass. The sp. g. is 2·88, and the silica-percentage 53·55. This rock would have to be classed as "andesitic basalt."

Hornblende secondary after augite is not at all frequently observed in these rocks. There is another lava on Seatoller Fell, a normal andesite, in which it occurs as prismatic grains of deep green colour, this being the only case in which I have observed hornblende in one of the regular local andesites. Original hornblende is never seen nor any sign that it ever was present. It seems probable that hornblende-andesites were never represented in the district.

Enstatite has been shown by Prof. Bonney (Geol. Mag. 1885, p. 77) to have been a constituent of some of the Eycott Hill lavas; and Mr. Teall supposes it probable that the andesites of the district contained it. I have sought carefully for it in many rocks from various localities, but have not found it, nor any secondary product which suggests it, in any undoubted lava. In a rock from Dale Head, of which I am uncertain whether it was a flow or an ash, there are good-sized serpentine-pseudomorphs after some mineral, which I think was very probably enstatite. The secondary mineral is not bastite. Again, in an ash or tuff from the summit of Sargeant Man a good deal of serpentine appears, some of it in the form of small prismatic pseudomorphs, contained in andesitic lapilli, strongly suggestive of original crystals of enstatite; and in a tuff from Glaramara one good-sized serpentine-pseudomorph is also seen, the form being quite that of the enstatites of andesites, etc.

It would seem likely that enstatite was a rare constituent of these rocks.

A rock occurs at Thornthwaite Crag, a little below the tall Cairn, which differs sufficiently from the usual andesites to be worthy of

mention. It is a grey-green, highly vesicular rock, the vesicles now filled with chlorite and chalcedony. In thin sections the difference alluded to is apparent in the felspars of the ground-mass. These to a very large extent consist of untwinned laths, many very elongated in proportion to breadth, and extinguish mainly quite parallel to their length. Such of them as are twinned are almost without exception binary twins, and of these a large proportion extinguish simultaneously and again quite parallel, or at very low angles. There are a good many square tabular sections also seen, more than in any other local andesites examined. The laths are of various sizes, and pass down to very small ones with mainly forked and ragged ends. So far as optic discrimination in thin sections is a guide, the felspar in this ground-mass seems to be mainly, if not almost wholly, orthoclase. There is a good deal of devitrified interstitial glass and the usual amount of diffused alteration-products. The porphyritic felspars are still fairly fresh, and several of them in some of the slides examined appear to be orthoclase, while in others they are wholly plagioclase, the ground-mass remaining as above described. In one hand-specimen there are large groups of felspar crystals clustered together in the manner described by Mr. Teall in the case of the Tynemouth Dyke; that is, they are *idiomorphic* towards the outside of the group, and *allotriomorphic* inside it. Some of these groups are so large that they give the effect, on fractured surfaces of the rock, of being infillings of good large vesicles with felspar, but the microscope shows their true nature.

Some of this rock was prepared for analysis by crushing moderately small and picking out sufficient bits quite free from vesicles or their contents. The analysis was kindly made for me by Dr. J. B. Cohen, of Owens College, and is calculated on dehydrated rock:—

Silica	= 58·69	per cent.	
Alumina	= 15·84	,,	
Ferric Oxide ...	= 8·62	,,	(Ferrous Oxide not determined.)
Lime	= 3·43	,,	
Magnesia	= 2·91	,,	
Manganous Oxide	= 0·58	,,	
Potash	= 3·86	,,	
Soda	= 5·06	,,	
	98·99		

These figures would stand equally well for a trachyte or an andesite, the proportions of the alkalies being much the same as in many analyses given of trachytes; agreeing for instance almost completely with one of the "typical analyses" given by Professor Cole in his "Aids in Practical Geology." It appears that whether a magma of certain composition will consolidate as trachyte or as andesite, depends largely on conditions other than purely chemical. The rock in question is not a trachyte, but it would become one by a very moderate degree of further differentiation from the accompanying andesites. Rocks with a closely similar orthoclase ground-

mass, and some apparently orthoclase porphyritic crystals, occur also near Keswick.

It is not at all unlikely that undoubted trachytes may be found in the Lake District. Sir A. Geikie, in his address above referred to, alludes to the general resemblance of these lavas to the "porphyrites" of the Old Red Sandstone in Scotland, and Dr. Hatch quotes the authority of Professor Judd for the fact that "excellent sanidine-trachytes" exist among these rocks at Haddington ("Introduction to the Study of Petrology," p. 100). Some lapilli seen in certain tuffs also suggest that good trachytes exist somewhere among the Lake rocks.[1]

Sir A. Geikie states that from the observations of himself and Dr. Hatch on the rocks of the Lake District, he concludes that lavas are much more abundant among them, relatively to "ashes," than was allowed by Mr. Ward in his Survey Memoir and other writings. In this conclusion it is probable that most workers in the district would now agree. But there are, of course, many cases in which it does not seem possible to decide whether they are flows or ashes, either in the field or with the microscope,—certainly not with the latter. The difficulties of this kind of examination are very fully (not to say a little gloomily!) put forth in a paper by Mr. Rutley ("On Community of Structure in Rocks of Dissimilar Origin," Q.J.G.S. vol. xxxv. 1879), and anybody who may be in danger of underrating these difficulties, or of getting too much confidence in his power to solve them, or indeed to solve any sort of questions whatever in microscopic petrology, would do well to read that paper.

The chemical and mineralogical changes which have taken place in these rocks are of very great interest in some cases. They are, however, most fully seen in the detrital rocks,—the ashes and tuffs,—and I hope to return to some of them in connexion with a study of the ash-slates, etc., of the district.

[1] Prof. Cole points out ("Aids in Practical Geology") that the older trachytes (or quartzless porphyries, orthophyres, etc.) may often be difficult to mark off from the rhyolites, and suggests that the marked absence of porphyrite quartz in some of the "altered rhyolites" may give rise to a suspicion that they were trachytes. There is a "rhyolite" exposed in the plantation in front of Shap Wells Hotel, which differs notably from the other rhyolites near to it. Macroscopically it shows crystals of felspar more prominently than any of the others do. Microscopically it shows an abundance of felspar-laths and microlites, all orthoclase, lying in a rather plentiful cryptocrystalline base, "speckly" in polarized light, apparently devitrified glass. Such laths and microlites are absent from the other local rhyolites. There is none of the spherulitic structure so abundantly developed in these rhyolites, and there is no sign of free quartz or of "granophyre." The silica-percentage of a specimen collected by me is 61·15, as contrasted with over 75 per cent. found in rhyolites of Wasdale Head and Stockdale by Mr. Garwood. The microscope shows nothing whatever to lead to the supposition that the silica-percentage has been lowered by decomposition or infiltration, the rock being very free from chlorite, etc. This was apparently never a rhyolite, but was most probably a trachyte with a large amount of glassy base.

III.—*Pholidophorus germanicus*: an Addition to the Fish Fauna of the Upper Lias of Whitby.

By A. Smith Woodward, F.G.S., F.Z.S.

SEVERAL species of Vertebrata are now known to be common to the Upper Lias of the neighbourhood of Whitby, Yorkshire, and the corresponding formation so widely developed in parts of Würtemberg and Bavaria. The recent discovery of another link between the two faunas in question thus seems to be worthy of placing on record. Moreover, the latest comparisons render it possible to assign to the fossil under consideration a more precise specific diagnosis than has hitherto been published; and the announcement of the discovery may lead to the recognition of other specimens besides those in the British Museum, with which alone as yet the present writer is acquainted.

The fossil in question is a Lepidosteoid fish, long ago observed by Quenstedt in the Lias of Würtemberg, and briefly described under the name of *Pholidophorus germanicus*.[1] A figure of the head and anterior portion of the trunk accompanies the original description; and it is satisfactorily proved that the fish is a typical species of the well-known early Mesozoic genus to which it is referred. It is the largest known Liassic species of *Pholidophorus*, attaining a length of nearly 0·3 m.

Two almost complete examples of the species, and four more fragmentary specimens were obtained from the neighbourhood of Whitby by the late Sir Philip Egerton and the Earl of Enniskillen. These at present form the series in the British Museum. They agree precisely in all their characters with several typical specimens of *Pholidophorus germanicus* from Ohmden, Würtemberg, in the same collection; and the chief points of specific importance are noted in the following paragraph.

As usual in *Pholidophorus*, the body is gracefully fusiform in shape. The length of the head with the opercular apparatus somewhat exceeds the maximum depth of the trunk, which equals about one-fifth of the total length of the fish. The rugose ornament of the head and opercular bones—especially that of the cranial roof—is very fine and conspicuous; and the rugæ on the maxilla and dentary bone tend towards a longitudinal striation. The pelvic fins arise slightly in advance of the middle point of the trunk, and are provided with small fulcra (as especially well shown by B. M. No. P. 1058). The dorsal and anal fins are of the ordinary small proportions, and the former is directly opposed to the pelvic pair. The scales are large and nearly smooth, but with a faint, coarse rugosity, most conspicuous in the caudal region; their hinder margin is very slightly convex, and not serrated; and there are at least six longitudinal series of flank-scales much deeper than broad.

Of the characters just mentioned, the peculiar ornament of the scales seems to be especially distinctive, and renders possible the

[1] F. A. Quenstedt, "Der Jura" (1858), p. 234, pl. xxx. figs. 9–11.

determination even of fragments. The feebly marked rugæ are broad and rounded, and towards the superior margin of the scales, more particularly on the caudal pedicle, they exhibit a tendency towards arrangement in a series of short, parallel, vertical folds.

IV.—*Pseudotrionyx* from the Bracklesham Beds.

By A. Smith Woodward, F.G.S., F.Z.S.

THE extinct genus of Chelydroid Chelonians to which M. Louis Dollo gave the name of *Pseudotrionyx*,[1] has already been recorded from the London Clay of Sheppey, by Messrs. Lydekker and Boulenger.[2] It is somewhat remarkable, however, that until the recent acquisition by the British Museum of the collection of Mr. J. B. Ogle, no certain evidence had been observed of the occurrence of the genus in the Bracklesham Beds—the English equivalent of the Bruxellian Series which yielded the Belgian *Pseudotrionyx Delheidi*.

This evidence is still very small, but appears nevertheless conclusive. It consists of one of the middle marginal bones, well preserved and showing the pit for the reception of the extremity of the rib. The bone measures 0·05 m. in length, 0·042 in the maximum width of the upper face, 0·03 in that of the lower face, and 0·018 in the maximum thickness of the angulation. Both the upper and lower faces of the bone are covered with the characteristic coarse, but faintly-marked pitted ornament; and the angulation of one extremity measures about 90°, while that of the other is slightly greater.

The fossil thus described agrees so closely in its proportions and sculpturing with the type-species *P. Delheidi* that, in the absence of further material, it may be assigned to this form.

V.—Notes on *Stereodon Melitensis*, Owen.

By John H. Cooke, F.G.S., etc.

IN the year 1865 portions of the upper and lower jaws of a large extinct fish that had been found imbedded in the Globigerina Limestone[3] of Malta were submitted by Dr. Leith Adams to Professor Owen for identification. Adams had considered them as being the remains of a crocodilian; but in a paper that appeared in the Geological Magazine for April, 1865,[4] Owen pronounced them to be the remains of a large extinct fish that belonged to "the cycloid order, and having sauroid dentition," and he proposed that "this fine addition to Miocene Tertiary fishes" should be known by the name of *Stereodon Melitensis*.

[1] L. Dollo, "Première Note sur les Chéloniens du Bruxellien (Eocène Moyen) de la Belgique," Bull. Mus. Roy. d'Hist. Nat. Belg. vol. iv. (1886), pp. 75–96, pls. i. ii.

[2] R. Lydekker and G. A. Boulenger, Geol. Mag. [3] Vol. IV. (1887) p. 274.

[3] Bed IV. The "freestone" of Spratt and Adams.

[4] "Stereodon Melitensis," Owen, Geol. Mag. April, 1865.

A portion of the bony skeleton of a fish of the same species was also discovered in the same locality; but as it was not sent with the other specimens, it has been neither figured nor described.

In the course of his paper Owen repeatedly refers to it, and finally concludes by saying, "It is much to be desired that the rest of the skeleton of this extinct fish should be figured." No attempt has, hitherto, been made to carry out this suggestion, and as no record of this interesting specimen exists, I have therefore visited the Malta Museum, wherein the fossil is now deposited, and have obtained the following particulars relating to it.

The specimen is oblong in shape, and measures $22\frac{3}{8}$ inches from the snout to the 10th dorsal vertebra. It consists of a fragment of the head, and a portion of the vertebral column, the latter of which extends as far as the 10th dorsal.

The vertebræ are circular in shape, and they form a continuous chain which curves slightly in a downward direction. They are well ossified, but, unfortunately, most of them have been badly developed from the matrix, and their characteristic features have thereby been obliterated. The 1st, 2nd, 3rd, and 5th are, however, in an excellent state of preservation; and the 10th vertebra distinctly shows deep lateral pits longitudinally extended. Each vertebra is bi-concave, and its body is somewhat depressed towards the middle. Compared with the posterior diameter, the antero-posterior diameter is much the shorter of the two.

Posterior diameter of the 6th dorsal vertebra	...	$1\frac{1}{2}$ inches.
Antero-posterior of the 6th dorsal vertebra	...	$\frac{3}{4}$ of an inch.
Posterior diameter of the 10th dorsal vertebra	...	$\frac{5}{8}$,,
Antero-posterior of the 10th dorsal vertebra	...	$\frac{3}{4}$,,

The average diameter of the posterior extremities is $1\frac{3}{8}$ inches.

Above and below each of the vertebræ exhibits a broad protuberance, which forms the base of a long, sword-shaped spine, the flattened sides of which lie in a plane with the vertebral column, while the thin edges lie in the direction of the articular facets. These spines are anchylosed with the neural and hæmal arches of the vertebræ. They average three inches in length, and half an inch in width. The neural spines spring obliquely upwards and backwards from the centrum, while those on the hæmal side spring obliquely downwards and backwards, and gradually become shorter and more slender as the caudal extremity is approached.

There are no traces of scales.

Considerable portions of the bones of the head have been preserved in the limestone matrix, but most of them are so crushed as to be quite unrecognizable.

A fragment of the left branch of the lower jaw, containing a tooth which is similar in every respect to those that formed the subject of Professor Owen's paper, is intact, and thus affords an opportunity for the comparison of the two fossils.

Highland House, St. Julian's, Malta.

NOTICES OF MEMOIRS.

I.—Geological Survey Publications.

1. The Geology of the Country around Mallerstang, with parts of Wensleydale, Swaledale, and Arkendale. By J. R. Dakyns, R. H. Tiddeman, R. Russell, C. T. Clough, and A. Strahan. (Parts by J. G. Goodchild, C. E. De Rance, G. Barrow, and F. H. Hatch.) 1891. pp. 213. Price 3*s.* 6*d.*

THE area described by the numerous authors in this Memoir is, for the most part, an elevated tract rising 2000 feet and more above the sea-level, and including the sources of the rivers Ure (or Yore), Swale, Lune, and Eden. The oldest rocks exposed belong to the Coniston Limestone Series, and of this series the Ashgill shales form the upper part, and the top of the Lower Silurian (or Ordovician). The lowest division in the overlying Upper Silurian system is that known as the Stockdale shales, and it is remarked that its base is determined principally on palæontological considerations, for there is an abrupt change from the fauna of the beds below, without any stratigraphical unconformity. Succeeding the Stockdale Shales are the Coniston Flags and Grits, and the Bannisdale Slates. Resting unconformably on the Silurian rocks comes the great Carboniferous series, including representatives of the Basement red conglomerate and sandstone (which may be of the age of the Upper Old Red Sandstone), Lower Limestone Shales, Great Scar Limestone Series, Yoredale Rocks, and Millstone Grit. The description of these rocks occupies the greater part of the Memoir, which indeed deals with the district of Uredale (Yoredale) or Wensleydale, from which the Yoredale rocks take their name. Some Permian and Triassic rocks, as well as Glacial Drifts and Recent deposits, are described. There are also notes on the Lead-mining, on the Coal-beds which occur in the Yoredale Series and Millstone Grit, and on the Building-stones.

Dr. Hatch contributes notes on the Eruptive rocks; and there is a list of Carboniferous fossils by Mr. Etheridge.

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2. The Geology of Parts of Cambridgeshire and of Suffolk (Ely, Mildenhall, Thetford). By W. Whitaker, H. B. Woodward, F. J. Bennett, S. B. J. Skertchly, and A. J. Jukes-Browne. 8vo. pp. 127. Price 2*s.*

IN this Memoir we have the accounts of the Oxford Clay, Corallian Beds, and Kimeridge Clay of the neighbourhood of Willingham, Upware, and Ely. Mr. T. Roberts has contributed a revised list of the Upware Fossils (from his, as yet unpublished, Sedgwick Essay of 1885); and Mr. E. T. Newton has some notes on the Vertebrata from the Kimeridge Clay, in the collection of Mr. Marshall Fisher of Ely. Then follow notes on the Lower Greensand and its Coprolite Beds, on the Gault, and on the several

divisions of the Chalk which includes the Coprolite Bed of the "Cambridge Greensand."

About half the work is devoted to Glacial and Post-Glacial Drifts, and this includes notes by Mr. Skertchly on beds at Culford, Mildenhall, and other places, where he obtained worked flints, believed by him to have come from strata older than the Chalky Boulder Clay; as Mr. Whitaker remarks, the question is whether the implements were really obtained from the beds in which they were reported to have been found.

A number of records of well-sections are given, and there are supplementary geological bibliographies of Cambridgeshire and Suffolk.

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3. Explanations of Horizontal Sections.

Nos. 130 to 139 have been prepared by Mr. C. Fox-Strangways, with the assistance of Mr. H. H. Howell, Mr. Clement Reid, and Mr. George Barrow. They give concise descriptions of the Jurassic, Cretaceous and other strata in various parts of East Yorkshire. Explanation of Horizontal Section, Sheet 140, by Mr. Horace B. Woodward, describes the Jurassic and other strata along a line from Bishopstone, near Hartwell, to near "the Centre of England" at Wibtoft in Warwickshire. These explanations are issued to the public at the modest price of 2*d.* each.

II.—Carboniferous Cephalopods. By Alpheus Hyatt. From Second Annual Report of the Geological Survey of Texas, 1890. pp. 329–356. (Austin, State Printing Office, 1891.)

THE descriptions given in this paper were taken partly from a collection forwarded to the author by Mr. E. T. Dumble, State Geologist of Texas, partly from specimens belonging to the United States National Museum, Washington, D.C., and partly from specimens belonging to private individuals whose names are given in connexion with the specific descriptions. As stated in an introductory note, the forms here described comprise a larger number of Carboniferous species than has hitherto been got together in a single publication. The genera represented are divided between the *Nautiloidea* and the *Goniatitinæ*. To the former belong *Temnocheilus* with five species (*Forbesianus, latus, conchiferus, depressus,* and *crassus,* the last three being new); *Metacoceras* with five new species (*cavatiformis, dubium, Walcotti, Hayi* and *inconspicuum*); *Tainoceras* with one new species (*cavatum*); *Domatoceras,* a new genus allied to *Centroceras,* represented by the new species *umbilicatum*; *Asymptoceras* with one new species (*Newtoni*); *Phacoceras* with one new species (*Dumbli*); *Ephippioceras* with one new species (*divisum*); and *Endolobus* with one new species (*gibbosus*). The *Goniatitinæ* are represented by the genus *Gastrioceras* with the new species *G. compressum.* The descriptions are accompanied by outline figures.

III.—Proceedings of the Cotteswold Naturalists' Field Club for 1890–91, Vol. X. Part 2, 1891.

THREE of the four papers in this Number of the Proceedings are devoted to Geology; even the address of the President, Mr. W. C. Lucy, is largely concerned with the same science, giving as it does accounts of excursions to Lydbrook and Symond's Yat, May Hill, Eastnor, Swindon, and Avebury.

The first paper is by Mr. H. D. Hoskold, and entitled "Geological Notice upon the Forest of Dean." In it the author gives a very full account of the formations, referring to the early work of Buckland and Conybeare, David Mushet, De la Beche, and others, and adding a number of new records of the strata passed through at various collieries. He estimates that the Forest of Dean contains nearly 250 millions of tons of coal available for use—the amount raised during 1888 was a little over 800,000 tons.

Professor Allen Harker contributes a paper "On the Geology of Cirencester Town, and a recent discovery of the Oxford Clay in a deep well-boring at the Water Works." He gives accounts of various wells in the neighbourhood, and announces the discovery of a small faulted tract of Oxford Clay that was proved by a boring at Lewis Lane, Cirencester. Important details of the Forest Marble and Great Oolite are given.

Dr. Frederick Smithe and Mr. W. C. Lucy furnish "Some Remarks on the Geology of Alderton, Gretton, and Ashton-under-Hill." Their descriptions refer to the Middle and Upper Lias, and they give lists of fossils from these formations at Alderton Hill. Among the records are *Ammonites radians* from the Upper Lias (lower part), and *A. aalensis* from the Middle Lias; identifications which we anticipate will be doubted by those who believe in the rigidity of zones.

REVIEWS.

I.—Systematic List of the Frederick E. Edwards Collection of British Oligocene and Eocene Mollusca in the British Museum (Natural History), with references to the type-specimens from similar horizons contained in other collections belonging to the Geological Department of the Museum. by Richard Bullen Newton, F.G.S. [With Appendix by G. F. Harris.] London, printed by order of the Trustees and sold by Longmans & Co.; B. Quaritch; Dulau & Co.; and Kegan Paul, Trench, Trübner & Co., Paternoster House, Charing Cross Road, W.C. 8vo. pp. xxviii. and 365, 1891.

THIRTY-SEVEN years have elapsed since the historic "Catalogue of British Fossils," by Professor John Morris, saw its second edition published; a modest work of 372 pages, 8vo., embracing all classes of fossil-remains.

Since that date, a long array of British Fossils have been figured and described, many groups of the Invertebrata being fully Mono-

graphed, as for example, the Brachiopoda, by Dr. Davidson; the Sponges, by Dr. Hinde; the Blastoidea, by R. Etheridge and P. H. Carpenter; the Merostomata, by Dr. Woodward. In others great progress has been made as in the Foraminifera by Carpenter, Parker, Jones, and Brady; the Hydroida by Nicholson; the Polyzoa, by Busk and Vine; the Trilobites by Salter and Woodward; the Entomostraca and Phyllopoda, by Prof. Rupert Jones; the Corals, by Prof. Duncan; the Echinoidea, by Wright; the Decapod Crustacea, by Bell and Woodward; the Cephalopoda, by A. H. Foord; and the Tertiary Mollusca, by F. E. Edwards and Searles V. Wood.

In Catalogues, serving as supplements to Morris, we have (1), a complete "Catalogue of British Fossil Vertebrata," by Arthur Smith Woodward and C. Davies Sherborn, 1890, 8vo. pp. xxxv. and 396; larger by 51 pages than the space occupied by Morris for the whole of the classes of Plantæ and Vertebrata in 1854. (2), Fossils of the British Islands Stratigraphically and Zoologically Arranged, Vol. I. Palæozoic, by R. Etheridge, F.R.S., 4to. 1888, pp. 475, giving 6022 species from the Cambrian to the Permian.

Mr. Etheridge tells us that Vol. II. Mesozoic, and Vol. III. Cainozoic, are *still in MS.*, and, adding their contents to the Palæozoic volume already published, we have 18,000 species of British Fossils, both Fauna and Flora, up to 1888.

Morris's Catalogue, up to 1854, records a total of 8359 species; so that, according to Etheridge, there had been an increase of at least 10,000 species in thirty-four years from 1854 to 1888.

The only other catalogues which supplement Morris's Catalogue are British Fossil Crustacea, by H. Woodward, F.R.S. (1877); Fossil Foraminifera, by Prof. T. Rupert Jones, F.R.S. (1882); Palæozoic Plants, by Robert Kidston, F.G.S. (1886); and lastly that of the Edwards Eocene Mollusca, by Mr. R. B. Newton, now before us (dated 25 July, 1891).

This important work gives us a carefully prepared record of 1229 described species of British Eocene and Oligocene Mollusca, distributed in 255 genera; 428 being Lamellibranchiata, 786 Gasteropoda, and 15 Cephalopoda.

In addition to the whole of the Edwards Collection, this volume also contains a record of all the "types" of Eocene Mollusca contained in the Bowerbank, Brander, Brown, Dixon, Gardner, Mantell, Prestwich, Shrubsole, William Smith, Sowerby, Wetherell, and Wise Collections, all preserved in the British Museum of Natural History. Every species bears after it its author's name, the date when given, and references to the principal works where it has been figured and described, with its synonyms, and lastly the horizon and locality in which it occurs.

570 MS. names of species, proposed by F. E. Edwards, are also given; but as these have never been described, they cannot be considered as of value, save as indicating that Mr. Edwards believed they marked new and undescribed species. Many of these names have been printed in various lists previous to the publication of Mr. Newton's Catalogue; and the author states (in

his Introduction, page v) his intention to describe and figure all those specimens bearing MS. names in due course; we hope he will keep his resolution strong, and get them all as speedily as possible stamped with the imprimatur of authority.

Apart from this, the work is a step in the right direction. which all who are interested in Malacology will be delighted to welcome. For many years past the nomenclature adopted for the fossil Mollusca in England has been much behind the times, many quite dissimilar forms being frequently included in the same genus. In the work before us, as the result of recent researches, many of these old genera have been split up into two or more genera, and although the older workers may denounce this as fiercely as in Joshua's days they cursed the man who removed his neighbour's landmark, nevertheless, in a more calm and philosophical state of mind, we are compelled to admit that these adjustments, if honestly and judiciously made, must be of material assistance to the student in the future, especially if he is attempting to correlate (as he ought) the recent with the fossil forms.

This revision has not been carried out always with equal rigour by the author. The old genus *Cerithium*, for example, has been very properly split up into several genera; but *Pleurotoma*, which also needed revision, is retained in full force, although numerous Malacologists have shown that it comprises many genera well known to the student of living mollusca.

Again, the genus *Chrysodomus*, in the work before us, includes a number of diverse forms which might have been dealt with more analytically by the author.

In a first attempt at completing such a task as was left behind unfinished by F. E. Edwards and Searles V. Wood, it must necessarily follow that much more is needed before the work can be said to be thoroughly accomplished.

In carefully following the original authors in their varied spelling of species, and terminations of the names, Mr. Newton has laid himself open to criticism from the more exact writers on recent and fossil shells, who would, in their earnest desire for uniformity, alter the terminations of such names so as to bring them all into one regular line, like a regiment under inspection; but, unless absolutely a misspelling, many writers consider such alterations of names actually wrong.

Thus Deshayes' name is used specifically in eight different genera, and by as many different authors, four species being spelt *Deshayesii*, and four *Deshayesi*. Similarly, we have *Bowerbankii* on page 22, and *Bowerbanki* on page 219; *Wetherellii* on page 26, and *Wetherelli* on page 215. In each case the names are by different authors, and given according to their own notions.

Some few specific names vary to the extent of two final letters. Thus we have *Cardium Etheridgii*, p. 51, and *Helix Etheridgei*, p. 270; *Aporrhais Sowerbii* (p. 97) *Bullinella Sowerbyi* (p. 266), and *Planorbis Sowerbyi* (p. 283); but different authors have each adopted their own termination, and these Mr. Newton has retained and respected.

In the matter of generic names, and the changes which they have

undergone, it would be no exaggeration to say that numbers of these genera have now as many aliases as a notorious pickpocket or a crack burglar.

If opinion as to the lines upon which alterations of names should be made was only unanimous, much labour would be spared. Some Naturalists hold that a name used for a genus of Vertebrates, as *Palæoniscus*, Blainville, 1818, for a genus of fossil fishes; and *Palæoniscus*, Milne-Edw., 1843, for a genus of fossil Isopods, need never disturb our peace of mind or our nomenclature; but it seems to be considered desirable that such repetitions should as far as possible be eradicated from the *Index Zoologicus*.

Names, once familiar as household words, are now constantly being swept away, and all our ancient landmarks cast down. But we are told it is for our good, and, like the "nasty doctor's stuff," we are bound to swallow it. We would like, however, to see these changes effected with more reverent and careful hands, and without that indecent haste which too often marks the action, as if the alteration of a name were a noble achievement in science, whereas it too often simulates, but in a more humble sphere, those barbarian conquerors of Egypt or of Nineveh, who erased every preceding monarch's name on temple and on palace and substituted their own. There is something more in science than a name, and those who would earn the gratitude of posterity may do so by adding to the walls of her ever-rising temple some well-worked stones: let whoever will, afterwards, cut or scratch his name thereon, he will at least have the nobler satisfaction of having done a piece of *solid work*.

The Introduction deals with the alterations in nomenclature made by the author; there is a good Bibliography (pp. 299–325), followed by a very useful Appendix prepared by Mr. George F. Harris, F.G.S., "On the Correlation of British with Continental Tertiary Strata," illustrated by a series of small tables and a large folding-table, which gives the equivalents for each horizon, as far as possible, for English and Foreign localities where Tertiary fossils have been obtained. This cannot fail to prove most useful to all students and workers in these deposits, and is an excellent piece of work.

We congratulate Mr. Newton on the completion of his Catalogue, and hope he will follow it up with figures and descriptions of the new or little known species of Eocene shells in the Edwards Collection in the British Museum.

II.—The Eocene and Oligocene Beds of the Paris Basin. By George F. Harris, F.G.S., and Henry W. Burrows, A.R.I.B.A. (A Paper read before the Geologists' Association April 3, 1891). Published by Edward Stanford (Price 3*s*.). 8vo. pp. viii. and 130. September 23rd, 1891. Illustrated by a Geological Map and numerous Sections.

THE Geologists' Association can no longer be spoken of as a *young* Society, and hardly deserves the title of a Society of *Amateur* Geologists. It was established in 1859, and is consequently in its thirty-third year, and numbers amongst its 550 members a large proportion of the most eminent and accomplished geologists and

palæontologists in England. Its Proceedings have become the depository of a most valuable series of Memoirs; the records and illustrations of its excursions, which extend to Belgium, France, and Italy, form a volume by themselves; and having, if we may assume, exhausted the geology and palæontology of their own country, they are attacking and peacefully re-conquering the ancient country of France, by publishing, in a separate form, a Memoir on the Eocene and Oligocene Beds of the Paris Basin. The authors of this work have qualified themselves for the task by repeated careful examinations of the French Tertiary area, and one of them by an extended traverse over other parts of the Tertiary formations of Europe. They justify the special study of the French Tertiaries on the ground "that no adequate conception can be formed as to the meaning and value of our own Tertiary beds and their organic remains without conjointly studying those on the other side of the Channel—especially in regard to the palæontological aspect of the subject." They point out that the Mollusca have always afforded the best basis for correlating the several horizons in France, Belgium, and England, by reason of their abundance, their wide distribution, and the very perfect state of preservation in which they occur, especially in the Paris basin; so that the French area supplies, as it were, the key by which to open up and interpret correctly the sequence and life-history of other Eocene and Oligocene strata in neighbouring areas.

The authors deal especially with the Mollusca, and in order to equip themselves thoroughly for the task, they have worked very carefully and critically over the great French collection acquired from G. P. Deshayes some forty years since, and preserved in the Geological Department of the British Museum (Natural History). These specimens bear, in almost every case, Deshayes' original labels, and therefore form a valuable basis for fixing their nomenclature even where, as in so very many instances, these names have now to be exchanged for more modern and presumably more correct determinations. They have also visited and examined the chief collections in Continental Museums.

Pages 1–44 of this Memoir are occupied with a carefully prepared description of the Eocene and Oligocene Beds of the Paris Basin, well illustrated with sections at Issy; at Cuise-la-Motte; at Arcueil; at Auvers; near Ver, on the road to Ermenonville; at La Chapelle-en-Serval; at Butte d'Orgement; and Quarry of Vintué, near Étrechy. In each, the lithological characters of the several beds are clearly given, as well as the typical Mollusca which mark each horizon. This is followed (pp. 44–56) by an Outline Guide to the principal sections and fossiliferous localities. Here is useful practical advice to collectors (p. 45). "A word or two as to the collection of fossil may be useful. Strong calico bags of various sizes, but mostly large, say 12 in. by 7 in. to 7 in. by 4 in. are the best receptacles for fossils, and they should be so made that the mouth can be drawn together and tied by tape. A brass ring sewn on enables several bags to be threaded on a strap and carried with ease, without fear of breaking."

"Sift! is the watchward in the Paris area, as the smaller species of

mollusca are always missed if this be neglected. Two wire sieves, one sixteen meshes and the other eight meshes to the linear inch, are suitable. A hammer is not often required; a pointed trowel, with a blade 5 in. or 6 in. long, is exceedingly useful for taking up the loose material. Some chip boxes, to hold the rarer or more delicate species, should be provided. A written label, tied to the ring of each bag, shows at a glance the locality and formation of the contents. For the fossils of the *Sables Inférieurs*, some preservative, such as potassic silicate, is required; or they may be brought away wrapped in cotton-wool, and subsequently treated. But by far the greater number of the fossils are in a magnificent state of preservation, and are easily collected and carried without the least risk of fracturing them." Thus equipped, and with Messrs. Harris and Burrows for travelling companions, we visit more than eighty localities, and have a really good time. Those who cannot arrange to be "personally-conducted" by the authors, must spend "three shillings nett," and have the benefit of their *printed directions*, without which it will be next to impossible to make a successful tour to the many widely-separated rural French districts. And here the excellent Map, which accompanies this book, proves most useful.

The last section (pp. 57–129) is occupied with a description of the Palæontology of the Eocene and Oligocene Beds of the Paris Basin.

The authors have received the assistance of Mr. Arthur Smith Woodward with the Vertebrata (a careful list of which is given, including Mammalia, 19 species; Aves, 12; Reptilia, 10 species; Pisces, 33 species). The Arthropoda are credited with 5 genera; the Echinoidea with 14 species; the Brachiopoda with 20 species; the Bryozoa with 4 species; the Actinozoa with 11 species; the Foraminifera are too numerous to catalogue. The Plantæ are briefly referred to. References are given to authors for the several groups; so that the student may go to the original works in every case.

The Mollusca occupy from pp. 63–124. Tables are given of all the species, arranged with columns showing the range of each from the Lowest Eocene; the Lower Eocene; the Middle and Upper Eocene. The Oligocene Mollusca form a separate table. These Tables of Genera and Species, which occupy 48 pages of the work, produce the following summary.

For the Eocene Beds of the Paris Basin :—

Pelecypoda or Lamellibranchiata (including additional species on page 114 supplied by Cossmann)	1083	
Oligocene Lamellibranchiata	112	
		1195
Eocene Gasteropoda (including additional species supplied by Cossmann, pp. 114–115)	2062	
Oligocene Gasteropoda	177	
Gasteropoda Pulmonata	70	
		2309
Eocene and Oligocene Scaphopoda	32	
		32
Eocene Cephalopoda	19	
		19
Total		3555

These figures convey an idea of the extreme richness of the Mollucan fauna of the Paris Basin, and show it to be at least three times as rich in species as the Eocene and Oligocene beds of the English area. This richness in species is also borne out in the vast numbers of individuals of the more common forms 'whose name is legion' in some spots.

We cannot close this brief notice without referring to the vast labour entailed by the preparation of a list of upwards of 3000 species, giving the range of each. Of course the works of Cossmann, Deshayes, and many others, have been used to aid this compilation, but the critical knowledge and care possessed and exercised by the authors could alone insure this part of the work being carried out correctly. The authors acknowledge that they have had valuable assistance in correcting their proofs from Mr. F. A. Bather, M.A., F.G.S., and in their biography from Mr. C. Davies Sherborn, F.G.S. There is an Index of Species and a General Index is also provided.

We heartily congratulate the authors on this valuable piece of work, and the Geologists' Association upon their courage in incurring the very large expense of printing it, which we sincerely trust they may recover on the sale of this very useful Memoir.

III.—The Physical Geology and Geography of Ireland. By Professor Edward Hull, M.A., LL.D., F.R.S., Second Edition, Revised, pp. 328. (London: Edward Stanford, 1891. Price 7*s*.)

AFTER an interval of thirteen years the author has given us a revised edition of his useful book, and, as he remarks, it comes by a happy coincidence concurrently with the completion of the Geological Survey of the country with which it deals. In bulk the work is larger by 37 pages, and it contains three more illustrations. Considerable portions of the work remain as in the original edition, but here and there corrections and additions have been made; the more important supplementary matter relating to the Archæan rocks, the Devonian rocks, the Volcanic rocks of Antrim, and to "the invasion of Ulster by a great ice-sheet from the Grampian Mountains of Scotland."

The work was reviewed at considerable length in the Geological Magazine for March and April, 1878 (pp. 121 and 167), and it is therefore needful only to draw attention to a few points in our present notice.

In the former edition Prof. Hull commenced with the Cambrian rocks; he now decides to "commence with the Archæan rocks, which are the oldest, and follow the course of the geological record downwards" (some would prefer to say *upwards*). A couple of pages serve to tell all the author has to say about these oldest of rocks, which consist chiefly of "gneiss with masses of schist." The principal areas occupied by these rocks are shown on the neat little geological map which accompanies this work, and the author candidly states, though in language that savours of a "bull," that with regard to his former conclusion (in 1882) that the granitic and gneissic

rocks of north-west Donegal were of Archæan age, "this view, for which there is much conflicting evidence, I have been obliged to abandon." We think the author is right in using the term Archæan as a general group-name for rocks considered to be Pre-Cambrian; but he makes no reference to the term "Dalradian" (derived from the old kingdom of Dalriada in the north of Ireland), that has lately been suggested by Sir A. Geikie for the crystalline schists of the north of Ireland and the centre and south-west of Scotland. Already Prof. Hull's remarks on the "Lower Silurian" rocks of Donegal may need revision.

In his account of the Old Red Sandstone the author employs the name Devono-Silurian for the Glengariff Grits and Dingle Beds, which he regards as equivalent to the Downton Sandstones of Hereford and the Foreland grits and slates of North Devon. These beds are surmounted unconformably by the Upper Old Red Sandstone, and thus there is a great gap that may be elsewhere represented by the Middle Devonian.

Indications are given of the zones in the Carboniferous Limestone, for the recognition of which the labours of De Koninck are acknowledged.

Some criticisms are called for by the Table of Formations given on page 3, for the "Liassic group" is separated from the "Oolitic or Jurassic group." Hence the author is led to remark that the whole of the Jurassic series is unrepresented in Ireland, whereas it is customary to include both Lias and Oolites in the Jurassic system. Again he has given in upward succession above the Oolitic or Jurassic group, and ranged in similar type as if equivalent in value, the Purbeck Beds, Wealden Beds, Neocomian Beds, and the Lower Cretaceous Beds; a very unfortunate grouping to say the least of it, although it is true that these formations are simply noted for the sake of comparison with those represented in Ireland.

The author criticizes the view (put forward by Sir A. Geikie) that the trachytes and pitchstones of Antrim are far younger than the surrounding basaltic sheets, and he refers to the occurrence of numerous pebbles of Tardree trachyte in the stratified ash-beds which overlie the lower basaltic sheets in certain localities.

The Pliocene age of the clays of Lough Neagh is still maintained by the author, although the occurrence of "bivalve shells resembling a species of *Unio*, or *Mytilus*," cannot be said to count for much.

A good description of the Glacial Drifts follows. These include Lower Boulder-clay, Middle Sand and Gravel and Upper Boulder-clay. "The Lower Boulder-clay is the most extensively distributed of all the Post-Pliocene deposits in Ireland." It is a stiff clay with striated blocks. The "Middle Sand and Gravel" is stated to contain marine shells in various places, and "may be regarded as a formation of marine origin, which has been strewn over the bed of a comparatively shallow sea." Yet we find it at elevations of 1300 feet. The author is disposed to think that floating ice may have had something to do with the accumulation of some of these gravels; but he is led to infer a great depression, which must have reached

1500 feet below the existing level. How to reconcile all the facts and explanations is left a good deal to the imagination of the reader.

The formation of the Lower Boulder-clay is held to be due to ice, "either in the form of a glacier, or of a sheet spread over the country, and moving in certain directions." The Upper Boulder-clay, which by-the-bye "may easily be mistaken for the Lower Boulder-clay," sometimes shows traces of stratification, and is "just such a deposit as might be supposed to have been formed under the sea, the waters of which were laden with ice-rafts and bergs bearing stones and boulders which would constantly fall to the bottom as the ice melted away; while these waters were themselves rendered turgid by streams from glaciers entering from various directions."

The *first* part of the work is thus taken up with an account of the many geological formations that occur in Ireland; the *second* part deals with physical geography, with the 'birthday' of mountains, the origin of the Central Plain, and of river valleys and lakes; and the *third* part is devoted to the Glaciation of the country, concluding with some account of the Prehistoric Mammalia.

The work is pleasantly written and well calculated to arouse an interest in Irish geology; and from its containing the matured views of one who for many years directed the Geological Survey of the country, it will be read with interest by geologists in general.

IV.—Some Recent Memoirs on Palæozoic Ostracoda.

I.—ULRICH, E. O., describing some new or little-known North-American Palæozoic Ostracoda (Journ. Cincinnati Soc. Nat. Hist., 1890 and 1891) adds very considerably to our knowledge of the—1. "Lower Silurian;" 2. "Upper Silurian and Devonian;" and 3. "Carboniferous" species. In the first group he finds reason to separate some known forms from *Beyrichia* as types of the new genera *Ctenobolbina* (with 5 species) and *Tretradella* (1 species); and to institute the new genera *Drepanella* (6 species) and *Jonesella* (4 species), both near *Bollia*. The other genera of this group, from Ohio, Kentucky, Tennessee, Indiana, Illinois, and Minnesota, here described and figured, are *Entomis*, 1 sp.; *Pontocypris* (?), 1 sp.; *Bollia*, 5 spp.; *Placentula*, 2; *Beyrichia*, 1; *Eurychilina*, 6; *Primitia*, 11; *Aparchites*, 1; *Leperditia*, 5 (including a clear determination of *L. fabulites*, Conrad): and *Isochilina*, 6 (one from Ontario). The second group come from Indiana, Ohio, and New-York State, and consist of *Leperditia*, *Isochilina*, *Aparchites*, and *Entomis*, 1 sp. each; *Æchmina*, 2 spp,; *Halliella*, gen. nov., 1; *Ctenobolbina*, 5; *Bollia*, 2; *Beyrichia*, 3; *Moorea*, 1; *Kirkbya*, 3; *Octonaria*, 4; *Bythocypris*, 3; *Bairdia* and *Pachydomella*, gen. nov., 1 sp. each; and *Barychilina*, gen. nov. 2. The third (Carboniferous) group comprises—*Leperditia*, 1 sp.; *Primitia*. 4 spp.; *Ulrichia*, 2; *Beyrichia*, 2; *Bollia* and *Moorea*, 1 each; *Kirkbya*, 5; *Cypridina*, *Cytherella*, *Bairdia*, and *Pontocypris* (?), 1 sp. each. The species are illustrated in eighteen

plates with numerous figures in each, rather rough in execution, but sufficiently true in essential features.

II.—Jones, T. R., in the Contributions to Canadian Micro-Palæontology, part iii. 1891, pages 57–99, plates x.–xiii. describes:—1. Fifteen species and varieties of Ostracoda from the Cambro-Silurian of the Provinces of Ontario and Quebec and of Lake Winnipeg, thirteen being new; 2. Nineteen from the Silurian of Anticosti and the Saskatchewan district, including ten new forms; 3. Nine from the Devonian of Lake Winnepegosis, the Athabasca River, Ontario (Thedford), and the Hay River near the Great Slave Lake, six being new. The close alliance of so many forms generically and specifically is noticed, and the varietal links defined; more especially the earlier representative forms or predecessors of species flourishing at a later period. Such predecessors, if not directly and genetically related, certainly occur in older deposits.

Thus the well-known Trenton species *Leperditia fabulites* and *Louckiana* are scarcely distinguishable from some forms of the later Silurian *L. Hisingeri*; and *L. labrosa* is very close to *L. marginata* of the same date. Even *L. balthica* has a corresponding form, of little difference, in the Chazy, here designated var. *primæva*.

Other North-American Ostracods were described and figured in the Quart. Journ. Geol. Soc. 1890, pages 1–31, plates 1–4, and pages 533–556, plates 20–21. It may be noted that—(1) "*Primitia Morgani*," p. 5, pl. 4, fig. 6, is now *Ulrichia*; (2) "*Beyrichia Buchiana*?" at page 16, pl. 3, fig. 25, is probably an imperfect specimen of Ulrich's *B. persulcata*; (3) "*Beyrichia Clarkei*" at page 17, woodcut fig. 2, is almost, if not quite, a *Bollia*; (4) The new genus proposed by Mr. Ulrich for *B. ciliata* (*note*, p. 19) and its allies is *Ctenobolbina*; (5) "fig. 17" at p. 27, 3rd line from the bottom, should be "fig. 12"; (6) "*Primitia Walcotti*," p. 543, woodcut fig. 1, agrees with Mr. Ulrich's genus *Barychilina*; (7) The Canadian specimens enumerated at pages 550–554 have been described in detail, together with others, in part iii. of the "Contributions to Micro-Palæontology," 1891.

III.—Krause, A.—Wissenschaft. Beil. Programm Luisenstadt. Oberrealschule, Berlin, 1891; and Zeitsch. Deutsch. geol. Gesell. 1891, pages 488–521, plates 29–33. The Ostracoda found in the Silurian rocks of the gravel-drift of North Germany, as determined by the author and others, are here enumerated; and forty-six species are critically noted and figured. In a comprehensive Table of these North-German fossils (pp. 514–521) 84 species (20 of them new), besides several varieties, belonging to 18 genera, are enumerated, and their distribution shown according to—1. Their association with certain typical species of *Strepula* and *Beyrichia*: 2. Their occurrence in three kinds of Lower-Silurian rocks (27 species): 2. In three Upper-Silurian rocks (57 species): 4. Occurrence in the Prussian districts: 5. The probable origin of some species from Sweden and the Baltic Provinces.

T. R. J.

REPORTS AND PROCEEDINGS.

Address to the Geological Section of the British Association, by Professor T. Rupert Jones, F.R.S., F.G.S., President of the Section, Cardiff, August 19th, 1891.

(*Concluded from the November Number*, p. 524.)

Looking at these Coal-measures alone, and considering that slow depression accompanied their formation, the mind is strained in estimating the time required for the gradual subsidence to 10,000 feet, with shallow water always in place, and jungle growing steadily after jungle, inundation following inundation at intervals,—and is somewhat confused in reasoning on the possible causes and the exact processes by which not only the sinking of this region of the earth's crust was brought about, but how, in turn, the 10,000 feet of new accumulations and deposits were raised into the great undulations, which Professor Ramsay has described and depicted in his Memoir before mentioned, and how and when they were slowly worn down day by day into the present beautifully varied surface of South Wales and adjacent country.

I may here remark that the analogous coal-field of Nova Scotia, investigated by Sir W. E. Logan, Sir J. W. Dawson, and others has a thickness of 14,570 feet, including seventy-six seams of coal and ninety distinct Stigmarian underclays.

Mr. W. Galloway communicated, in 1885, to the Cardiff Naturalists' Society[1] some valuable observations on both the vertical and the horizontal occurrence of different coals in South Wales; and showed by a map (pl. iii.) where the 'seam-coal' mainly exists in the large *eastern* third; the 'intermediate coal' in the narrow *middle* third; and 'anthracite' in the *western* third of the Glamorgan-Monmouthshire area. He refers to the gradual transition from bituminous to anthracitic coal along a hypothetical *plane* passing through the coal-field, with its major axis lying E.N.E.—W.S.W., and its minor axis dipping at a very low angle towards S.S.E. He accepts Professor Geikie's tabular scheme of the strata at p. 24. Mr. W. Galloway has favoured me with the following remarks on the *vertical* place of the several kinds of coal in the series :—"The *long-flaming* bituminous seams are about 700 yards higher in the ground than the semi-bituminous seams; the semi-bituminous, or good *steam-coal* seams are 200 or 300 yards above the *dry steam-coal* seams; the last are perhaps 300 yards above the *bastard anthracites*; and these *inferior anthracites* may be 400 yards or more above the perfect *anthracites*. You have thus somewhere about, say, 1500 or 1600 yards from the *long-flaming* coals to the *anthracites*. It may be a good deal more in some parts of the coal-field; but, as the deepest shaft is only about 800 yards, we cannot get a direct measurement."

Of these three sorts of coal—the *long-flaming dry* coals above have some seams suitable for gas-making; the middle are *caking coal*, good for making coke; the others produce *dry steam-coal* and *anthracites*.

6. *Output of Coal in South Wales.*—The following is the official account of the quantity of coal raised in South Wales last year as compared with that got ten years ago :—

[1] Trans. vol. xvii. 1886, pp. 20–34.

Table showing the Output of Coal in the South Wales District in the Years 1880 *and* 1890.

County.	1880.	1890.	Increase or Decrease in the ten years.
	Tons.	Tons.	Tons.
Breconshire	100,616	259,260	+158,644
Caemarthenshire	625,933	762,032	+136,099
Glamorganshire	15,320,096	21,426,415	+6,106,319
Monmouthshire	5,039,549	6,895,410	+1,855,861
Pembrokeshire	79,386	71,908	−7,478
Totals: South Wales.	21,165,580	29,415,025	+8,249,445

Total Output for the United Kingdom.

	1880.	1890.	Total Increase in the ten years.
England, Wales, Scotland and Ireland ...	Tons. 146,969,409	Tons. 181,614,288	Tons. 34,644,879

Dr. E. Hull refers to the increased production in the South-Welsh Coal-field, together with remarks on other fields and the future supply and working of coal, in the "Transactions of the Edinburgh Geological Society," vol. vi. part 2, 1890, where also Mr. H. M. Cadell follows with valuable notes on the probable future of the coal-trade.

7. *Varieties of Coal.*—The coal of the British Coal-fields exhibits every variety of composition between *anthracite*, which is nearly pure carbon, and the so-called *bituminous coals*, such as ordinary coal and cannel coal (hydrocarbons), rich in hydrogen. Anthracitic beds are rarely seen except in districts where the strata have been much disturbed, or peculiarly affected by other circumstances. Heat, whether direct or induced by pressure, vertical or lateral, has probably been the important agent in depriving coal of its hydrogen with some of its carbon, and thus changing it into anthracite. Neither in this latter nor in the compact cannel coal are the laminar structure and symmetrical jointing so distinct as in the ordinary coals. The last lose their volatile hydrocarbons also by exposure to the air, at outcrops and in open faults; hence they are not nearly so good for burning as those got at a greater depth. As it is well to have definite notions as to the appearance and structure of the different kinds of coal, some notes on the several sorts will now be offered.[1]

Anthracite is glossy or semi-lustrous, sometimes iridescent; it ignites with difficulty, and burns without smoke, and with little flame, on account of no volatile hydrocarbons being formed during combustion. This purely carbonaceous material differs from ordinary coal by its brilliant, semi-metallic lustre, its greater density, hardness, and brittleness, and by its massive and conchoidal fracture with sharp edges. Some of it can be cut or turned on the lathe into fancy articles.

Called *anthracite* (from ἄνθραξ, coal) by Karsten and the older mineralogists, it is also known as mineral carbon, blind-coal, stone-coal, culm, glance-coal, and non-bituminous coal. It is mentioned by mineralogists and geologists as having been found at many places in the Alps, Pyrenees, France, Germany, the United States, and the British Isles, under various geological conditions; but in regular and extensive beds it occurs chiefly in Pennsylvania, and largely also in South Wales. It is reported to have been found in China and elsewhere.

In the Franco-Belgian coal-field the coals become more and more anthracitic as they pass down to greater depths; both kinds, therefore were of the same age in

[1] Much information as to the constitution of coal and its varieties is given in Roland and Richardson's *Chemical Technology*.

formation; in South Wales also, as already stated, the anthracite and the other coals are all of one age. The squeezing, faulting, and inversions in the former field are accompanied by an alteration of the highly bituminous coals into *dry coals and anthracite*.

An interesting historical sketch of the use of anthracite, and some systematic remarks on its distribution in South Wales, were given by J. P. Bevan, F.G.S., in the "Geologist," vol. ii. 1859, pp. 75–80.

The anthracite of Pennsylvania is traceable from the inner folds of the mountain chain, where the strata have become more and more crystalline, and contain graphite as well as this non-bituminous coal, westward into Ohio, where the same beds consist of ordinary coal. In the eastern part of the Alleghanies the coal has only 6 to 14 per cent. of volatile matter, further west 16 to 22 per cent., 30 to 35 per cent., and in Ohio 40 to 50 per cent. (Prestwich). This coal-field before compression was probably 900 miles long by more than 200 broad in some places (Lyell).

The depression of strata by accumulated sediment above them may raise their temperature by the rise of the isogeotherms (surfaces of equal subterranean temperature), and they may reach a relatively high temperature. "Mere descent to a great depth, however, will not necessarily result in any marked lithological change, as has been shown in the cases of the Nova-Scotian and South-Welsh coal-fields, where sandstones, shales, clays, and coal-seams can be proved to have been once depressed 14,000 to 17,000 feet below the sea-level, under an overlying mass of rock, and yet to have sustained no more serious alteration than the partial conversion of the coal into anthracite. They must have been kept for a long period exposed to a temperature of at least 212° Fahr. Such a temperature would have been sufficient to set some degree of internal change in progress had any appreciable quantity of water been present, whence the absence of alteration may perhaps be explicable on the supposition that those rocks were comparatively dry."[1]

Coal in contact with granite is changed into anthracite or graphite; when in contact with volcanic and trappean rocks, it may become coke (columnar or otherwise) or mere soot.

Steam coal is very compact, burns with little smoke, and contains so little bituminous matter that it is not liable to spontaneous combustion, whether pyrites be present or not. It is an intermediate kind of coal, having more hydrocarbon than any anthracite has.

Ordinary coal, common coal, household coal, pit coal, black coal, coal proper, bituminous stone coal; of this there are several sorts:—

1. *Caking coal, coking coal, bituminous coal* (not really bituminous, but containing the constituents of bitumen—7 to 9 per cent. of hydrogen, with carbon and oxygen, or 4 to 6 per cent. of hydrogen and 6 to 8 per cent. of oxygen). When heated, it undergoes a kind of fusion and 'cakes' together, one piece adhering to another by the soft bituminous matter into which it is mainly changed. Such coals are used for *coking*, coke being more or less impure carbon left after the hydrocarbons have been driven off.

2. *Cherry coal*, or *soft coal*, is thinly laminated, soft, velvety, *short-fractured, friable*.

3. *Splint coal* (breaking off in long 'boards,' and into fragments with angular ends called 'splints'—Mushet), *bone coal, hard coal, free-burning coal, dry coal* (passing into *shaly, slaty*, and *stony coal*). This is less bituminous than some of the foregoing; burns free and open (that is, without swelling and caking), with a long smoky flame; with less than 6 to 8 per cent. oxygen and 4 to 6 per cent hydrogen; it is also called *dry coal*. The *hard coal* comes out in long blocks; the *cherry coal* in short pieces.

Reedy coal has alternate layers of *splint coal* and *bright coal* (Mushet).

Cannel coal, or *parrot coal*, is compact, and varies from lustrous to a dull earthy aspect; breaks irregularly, but with a conchoidal (shell-like) fracture; can be polished and cut into ornaments in a lathe. Yields mineral oil by distillation. Much used in gas-making; not fit for coking.

Torbanite, Torbanehill mineral, Boghead cannel-coal, or *Boghead coal*, is a kind of dark brown cannel-coal, good for making gas and oil (parrafin, etc.), and gives a light, spongy coke. It consists of minute light brown granules of hydrocarbon, with some earthy matter and portions of the tissues of coal-plants.

[1] Geikie, "Textbook," etc., 2nd edit., 1885, p. 273.

As a scheme for the general classification of coals the following table may be useful:—

Highly Bituminous. ...	Gas coals	Torbanite, cannel-coal, parrot-coal	Vegetable matter much altered.
		Tasmanite, Better-bed coal, etc.	Spore-coals.
Common Bituminous ...	Household coals ..	Caking and coking coal, cherry coal, splint coal, and other coals	Laminæ of charcoal (mother-coal) & hydrocarbon.
Semi-bituminous. ...	Free-burning steam coals ...	1. Charcoal deposited abundantly at first. 2. Hydrocarbon partially lost by change.	
Anthracitic ...	Nearly smokeless steam coal ...	Hydrocarbon nearly all lost by change.	
Anthracite ...	Smokeless coal ...	All the hydrocarbon lost by heat under pressure.	
Coke	1. Natural ... ... 2. Artificial ...	Hydrocarbon lost by heat without pressure.	

8. *Constituents of the Coal-measures and of Coal.*—Sandstone, shale, coal and clay, in successive repetition, constitute (as we all know) the main materials of the 'Coal-measures' ('measures' being an old mining term for strata). Each of these substances well deserves the close investigation they have received from numerous observers. We need not take the sandstone in hand now; it will be enough to say that the quartz-grains have been derived from the quartz of the same granite rocks which gave the little mica-flakes to mix with much of the sandstone, and the kaolin to form the basis of the shales and clays in the same great Carboniferous formation.

Shales and Ironstone.—The *shales* are varied; some are almost purely argillaceous; others contain carbonaceous matter in different proportions, even becoming quite black and bituminous. The lighter-coloured shales often have plant-remains, especially ferns, scattered through them, and even whole stems and branches of *Lepidodendron* and *Sigillaria*, squeezed flat, and reaching long distances. The darker shales also have plant-remains, but less perfect, and very often shells and other fossils, including relics of fish and numbers of small bivalved crustaceans; with regard to the last, the fishes, when alive, fed on the Cypridæ and other organisms, and in turn these little Ostracoda ate the dead fishes when they could.

Here and there are more or less continuous layers of *ironstone*, or more frequently groups of nodules parallel with the planes of bedding, and containing either parts of plants, more rarely small limuloids or other crustaceans, or even spiders, scorpions, insects, or relics of fishes and amphibia. In some cases the shales are of marine origin, judging from the character of the shells imbedded in them; but usually the evidence from the fossils is of a negative character. The shells that were formerly thought to be mussel-shells, like freshwater Unios, are now known to belong to a different family; and, not being quite the same as any known sea-shell, they may have been estuarine.

The nodular and the flat masses of clay-ironstones in the shales have been due to the formation of carbonic acid in the water and mud by the decomposition of vegetable matter and the removal of some oxygen from the peroxide of iron present there, and by the carbonic acid thereupon forming carbonate of iron. This then segregated around some organic object in the mud, and, mingled with clay, gave rise to nodules or larger masses of argillaceous ironstone.[1] In consolidating the nodules frequently split internally, and the fissures of retreat, filled with calcite, blende, pyrites, or other mineral, constitute *septa*, or divisions, in the *septarium* or septarian nodule. The so-called 'beetle-stones' are septarian nodules broken across, showing central and diverging lines.

The iron-ores of South Wales are fully treated of in the 'Memoirs Geol. Survey,' Iron-Ores, part iii. 1861, by E. Rodgers, and their fossils by J. W. Salter. From official sources we learn that the details of Production of Ironstone, chiefly Argillaceous Carbonate, from mines under the Coal-mines Regulation Act, for the year 1889 were—

[1] De la Beche, "Memoirs Geol. Survey," vol. i. pp. 185, 186.

County.	Quantity.	Total quantity.	Average price per ton.	Total value of ironstone at the mine.	Amount of metal obtainable
	Tons.	Tons.	*s.* *d.*	£	Tons.
Breconshire (Eastern part of	50	512	11 6	29	
Breconshire (Western part of	462		9 0	208	
Caermarthenshire	—	118	9 0	53	
Glamorganshire ... (Eastern part of	—	23,764	9 0	10,694	12,548
Glamorganshire ... (Western part of	23,764				
Monmouthshire	—	17,435	11 6	10,025	
	24,276	41,829	—	21,009	—

In Mr. J. P. Lesley's "Manual of Coal," etc. 8vo. Philadelphia, 1856, at pp. 22, etc., the variations in shales, and their passage even into coal, as the proportion of carbonaceous (vegetable) matter increases by local conditions, are carefully detailed.

Coal, Mother-coal, Coal-balls, etc.—The *coal* itself, to which the shales ('batts,' 'binds,' etc., as they are variously termed) usually serve as a roof, or in which they form 'partings,' or thin intermediate layers, comes next to be considered. Some remarks on the different kinds of coal have already been made. Common black coal is easily seen to be composed of thin alternate laminæ of dull and bright material, and usually the blocks or pieces have flat sides nearly at right angles with those delicate layers of deposition. These faces are due to shrinkage-joints; one is termed the 'face' (as it is presented on the long edge of the seam exposed in working), or the 'bord,' and the other or cross joint is the end; the former is also called the 'cleat,' and this term is sometimes applied to both sets of joint-divisions. The block of coal usually breaks also along the flat laminæ, exposing a somewhat dull, charcoaly surface, more or less interfered with by the next-lying bright lamina. The dull parts are real charcoal, or decomposed wood, and soil the fingers when touched; whilst the bright, or hydrocarbon, portion keeps clean when dry. On the fire the coal breaks more easily along the laminæ, because the bright portion softens and swells up with its bituminous change, and the 'mineral charcoal,' or 'mother-coal,' keeps the portions distinct for a time; so also the jointings open then, or give way easily to the poker.

The *mineral charcoal* may readily be seen to be flat fragments of woody tissue in a carbonised state; it is more or less impregnated with bituminous or mineral matter from the associated beds, and retains the mineral matter of the original wood. It is due to "the chemical changes experienced by woody matter in decay in the presence of air," when "wood parts with its hydrogen and oxygen and a portion of its carbon, in the forms of water and carbonic acid. . . . Under water, or imbedded in aqueous deposits, the principal loss consists of carbon and oxygen; and the resulting coaly product contains proportionally more hydrogen than the original wood. This is the condition of the compact bituminous coal."[1]

The 'mother-coal' necessarily indicates a periodical change (maybe that of the rainy season) in the formation of a coal-seam, for it lay exposed, as decaying wood, whilst that which was accumulated just before must have been sufficiently covered up by water (a few inches may have been enough) to undergo the advanced chemical changes causing a proportional increase of hydrogen. The dead sticks and stems projecting out of and above the water-covered peaty mass below would naturally supply the decaying touchwood and charcoal now lying as described above.

Doubtless a progressive change in the elaboration of hydrocarbon soon took place to some extent, even as it does in peat; but probably it was not completed in the compact coal until many layers of both vegetable and earthy matters had been accumulated (the former in place, and the latter from inundation), and caused some amount of pressure and consequent heat.

As, under favourable circumstances, the bright coal can be seen to have been made up of spores, leaves, branches, and stems of special trees, and other plants, the place of growth must have been a swampy forest or jungle, of enormous extent,

[1] Dawson, *Quart. Journ. Geol. Soc.*, vol. xv. 1859, pp. 627, etc.

probably in a warm (perhaps sub-tropical[1]) climate, to account for the hundreds of square miles of continuous coal-seams.

Much has been learnt from the broken and rotting ruins of a forest, standing on an area of the coal-growth, having been here and there sealed up and preserved in that original state, before hydrocarbonisation had proceeded far; whilst the rest of the fallen timber and accumulated relics passed into the state of bright coal, and became almost undistinguishable as to its structure except under the microscope after special manipulation. The 'coal-balls' of Oldham, in Lancashire, and the 'bullions' at South Owram, in Yorkshire, are calcareo-carbonaceous nodules, having been formed by the infiltration of water carrying carbonate of lime from the shells in an overlying shale down into the bed of woody fragments and other bits of dead plants. The carbonate of lime there segregated from the mass to certain centres, and preserved, in round nodules, the vegetable structures, before they were quite decomposed, more or less distinct as they had fallen on the forest floor. Hooker, Binney, Williamson, and others have elucidated much of the botany of the coal from this source.

In the Lower Carboniferous series at Pettycur Bay, Burntisland, in the Firth of Forth, are some well-preserved relics of the materials which would otherwise have been used to form a coal-seam (referred to by Williamson and Binney). In this case volcanic material has been ejected into or through a peaty mass, and, having removed by force some of the soft wet material, has been mixed up with it and settled down as a hard stratum, with well-preserved fragments of wood and other tissues, into which carbonate of lime was subsequently infiltered (Carruthers).

A third instance was discovered by Mr. Wünsch, in 1865, in the Lower Carboniferous series on the north-eastern shore of the Isle of Arran, where numerous plant-remains are well preserved in and under volcanic ashes. The strata are alternate sandy shales, thin coal-seams, and peperino-like tuff. Numerous truncated trees remain upright, rooted in the shale. *Sigillaria*, *Lepidodendron*, *Lepidophloios*, and *Halonia*, besides *Sphenopteris* and other ferns, are present.[2]

Cannel, etc.—Under the name of 'cannel' are known some important varieties of coal, useful for distillation and gas-making; and certainly they differed in their method of deposition both from ordinary coal and in some particulars among themselves. They all appear to have been formed of vegetable matter that, having been soaked and macerated to a black pulp, like the most rotten and semi-fluid peat, in lakes, lagoons, or other limited water-areas, became homogeneous masses of hydrocarbon, with much still discernible vegetable tissue, and occasionally with bones, teeth, and scales of fishes, and remains of *Amphibia*. Earthy matter was sometimes mixed with the cannel; and occasionally so much accumulated that the black mud graduated into carbonaceous shale. Light substances would also have been blown into the water by wind. According to the relative abundance of yellow-reddish hydrocarbons and macrospores, or of amorphous black substance (carbon) and microspores, is the difference between black and brown cannel (Carpenter).

Elsewhere the condition and place of the cannel are such as to suggest that, like a burst peat-bog of the present day (Buckland), the fluid carbonaceous pulp escaped from its birthplace, and found local hollows at lower levels that could receive and keep it. It is also suggested that such black, decomposed, fluid refuse of a swampy jungle, bordering a lagoon, might drain into the water, and settle as carbonaceous mud, or as coal itself, among the water-plants there (Grand'Eury). If poured in suddenly, it probably overwhelmed and poisoned many fishes. "The cannel coals, being wholly subaqueous, have not formed and do not possess mineral charcoal" (Dawson)

Torbanite consists almost entirely of minute sub-globular accretions of hydrocarbon (amber-coloured by transmitted light), derived either from chemical change of plant-remains, or more probably, directly from lycopodiaceous spores.

Spore-coal.—Very much of the substance of some coal-beds consists of lycopodiaceous spores that have been traced to the great lycopods, *Lepidodendron* and *Sigillaria*, allied to the club-mosses and *Selaginellæ*, and were probably shed periodically in enormous quantities (Prestwich and Morris, Hooker, Binney,

[1] A great predominance of ferns and lycopods indicates moisture, equability of temperature, and freedom from frost, rather than intense heat (Lyell).

[2] Geol. Mag. 1865, and Trans. Geol. Soc. Glasgow, 1882.

Williamson, Carruthers, Balfour, Huxley, E. T. Newton, Orton, Dawson, Rheinsch, Wethered, Bennie, Kidston, and others). Mr. E. Wethered has suggested that the chief material in common coal was derived from the spores of a water-plant nearly allied to *Isoëtes*, and that woody material has supplied but little of the hydrocarbon. He objects to the theory of "submerged forests" because of the difficulty that Professor Dana has described, resulting in the calculation that for a four-foot seam of coal there would be required a thickness of 32 feet of accumulated forest vegetation and 48 feet for four feet of anthracite.[1] The macrospores of *Isoëtes lacustris* have been found in the mud dredged in Loch Coulter, Stirlingshire, by Mr. Thomas Scott.[2]

"Dawson is disposed to think that the tuberin of cork, of epidermis in general, and of spore-cases in particular, is a substance so rich in carbon that it is very near to coal, and so indestructible and impermeable to water that it has contributed more largely than anything else to the mineral."[3] Prestwich refers to these, and especially to gums and resins, as main constituents of the coal; and argues that the climate was warm and moist, with a larger percentage of carbonic acid than exists at the present day, and a more rapid plant-growth.[4]

Messrs. Bennie and Kidston[5] have not only carefully given the botanical history of *Lepidodendron* and *Sigillaria*, and of their fructification, but have described the spores met with in their examination of the Scotch Carboniferous strata, and have given their conclusions as to the nature and condition of the beds from which the spores were collected. The splint and parrot coals yielded most; the cherry or soft coals are too far bituminised to show them clearly, though present. Some fireclays yield them in the upper two or three inches. Some thin shales (plant-beds and lakes) yield spores, and some have plant-remains as well. "Carbonised wood was common in all the poor or shale-like coals. . . . Some of the thin coals were almost entirely composed of such carbonised vegetable matter." Fragments of scorpions and eurypterids occur plentifully in some of the 'old soils' (fireclays). The former, being land-animals, and probably adapted to a hot (or, at least, warm) climate, are among the most interesting of the coal-fossils.

Drift-coal.—Formerly, more so than now, it was thought by some that the coal had been formed by the accumulation of drifted timber and floating masses of vegetation in rivers and estuaries. There are several difficulties in the way of this hypothesis. There would have been more ash in the coal, because the water would shift and deposit sand and clay, together with rafts and grass islands; and the ash of pure coals agrees in relative quantity and composition with the earthy matter naturally contained in plants (Green and others). How far a calculation could be made as to a given quantity of ash in coal, and the amount of mineral matter belonging to plants, as a basis for proving the original quantity of woody matter concerned in a given quantity of coal, would be difficult to determine, for some of the original mineral constituents have been probably removed by percolating water.

Professor Lesley[6] has calculated that the Mississippi could not supply by driftage from the forests of its valley in 100,000 years wood enough for one of the Schuylkill anthracite beds; mineral sediments would also interfere with the results. Under favourable conditions, he adds, tropical forests (Central Africa) and coast-swamps (Florida, Guiana, India) would supply good and sufficient material. So also the swamps of the 'Sunk country' of Arkansas and Louisiana, as well as the 'Great Dismal Swamp' in Virginia, for one set of conditions (Lyell); and the mangrove jungles in the West Indies and elsewhere for another.

Fireclay, underclay, undercliff, underbed, seat-earth, seat stone, bottom-stone, spavin, clunch, fake, pouncin. This is usually a dense clay,[7] but sometimes sandy,

[1] Journ. Roy. Microsc. Soc. ser. 2, vol. v. 1885, pp. 406–420.
[2] Report of the Fishery Board, 1890.
[3] Balfour, "Palæontological Botany," 1872, p. 67.
[4] Geology, vol. ii. 1888, pp. 117–120.
[5] Proceed. Royal Phys. Soc., Edinburgh, vol. ix. 1886, pp. 82–117.
[6] 'Manual of Coal,' etc., 1856.
[7] In examining microscopically the ultimate particles of some shales and underclays, Mr. W. M. Hutchings has discovered that these are composed of a 'micaceous deposit,' in which there is some fragmental mica, but that the mass appears to con-

and even altogether a hard sandstone ('ganister'). It varies in colour from black to white; and is from six inches to ten feet or more in thickness. A characteristic feature is its being penetrated in all directions by the stigmarian roots and rootlets of the trees (*Sigillaria*, *Lepidodendron*) that grew on it when it was the soil of the coal forest, having been slowly deposited by the quiet, shallow, muddy waters that succeeded the deposition of shale or sandstone by waters with stronger currents, these last terminating one of the periodical disturbances to which the many stages of gradual subsidence gave rise. Every coal-bed (or coal-seam, according to the application of those words to either a simple or compound layer of coal) lies on a more or less distinguishable 'underclay'; but this is often omitted to be recorded in coal-mining sections and documents.[1] Sometimes an underclay forms a roof of a coal; but it is the seat-earth of a coal lying on it.

Denudation.—Among the many examples of denudation in the Coal-measures, coal-beds have been washed away from their underclays; but these latter are so greatly toughened by their contained network of roots that they have more effectually resisted denudation. Both coals and underclays, however, were not unfrequently destroyed, or, at least, deeply and widely channelled by contemporaneous floods and rivers; for not only are the 'horses,' 'lows,' and 'washes' such watercourses, but the occurrence of pebbles of coal and small detrital particles scattered through some of the sandstones are due to similar denudation.[2]

Sir J. W. Dawson, in 'Acadian Geology,' 1868, p. 139, states:—"The occasional inequalities of the floors of the coal-beds, the sand and gravel ridges which traverse them, the channels cut through the coal, the occurrence of patches of sand, and the insertion of wedges of such material splitting the beds, ... are constantly represented in modern swamps and marshes, more especially near their margins, or, where they are exposed to the effects of ocean storms or river inundations." The great thickness of coal and carbonaceous shale in the Albion Coal-measures at Picton, Nova Scotia, were formed in a depression separated by a shingle bar (conglomerate) from the more exposed flats outside.[3]

9. *Fossils of the Coal-measures of South Wales.*—An examination, or even an enumeration, of the fossils would be much more than we have time for now, whether we took in hand the *plants* or the *animals*.

I. Of the characters of the former[4] we have indicated some particulars, such as facts about the spores and roots of the gigantic trees of which the humble *Selaginella*, *Isoëtes*, *Sphagnum*, and *Equisetum* are the living representatives. Descriptions of their roots, trunks, leaves, woody and other structures have been given to the world by both Foreign and British palæobotanists in numerous goodly memoirs and volumes, illustrated with excellent plates; and the many ferns, tree-ferns, and cycadaceous plants (the last known by their fruits chiefly) have been well described and figured. Kidston's 'Catalogue of the Carboniferous Plants in the British Museum' gives full references to many of the above, and the others are well known. With increased knowledge, the supposed dome-like, long-armed, stigmarian plants, with subaqueous leaves or processes, either floating on or in the water, or growing on the mud, have become the depressed stools, dichotomous roots, and innumerable long, narrow, leaf-shaped rootlets of *Sigillaria* and *Lepidodendron* (Binney and others). C. Grand'Eury, however, still distinguishes some perfectly aquatic and peculiar plants, which floated in the water with their roots trailing on the bottom; and of *Stigmaria* he holds the opinion that it indicates a formation in deep water, contrary (as he says) to what is generally stated.[5] The supposed palms have disappeared in the explanation that the supposed fruits are only the marks of compressed gas bubbles fixed during their escape from the fœtid black, decomposing mud.[6]

sist mainly of minute, rutiliferous, mica-like flakes, regarded by him as of secondary origin, made from the original components of the stratum (Geol. Mag. 1890 and 1891). Mr. Hutchings kindly informs me that, of the numerous fireclays which he has examined, several are being used for brick-making (Letter, May 20, 1891).

[1] De la Beche, Mem. Geol. Survey, vol. i. pp. 173 and 177.

[2] Logan, De la Beche, Buddle, and others.

[3] Dawson, Q.J.G.S. vol. x. p. 46.

[4] A useful compendium of our knowledge of coal-plants in 1863, by Professor John Morris, was published in the Proceedings Geol. Assoc. of that date.

[5] Mém. présentés, etc., Acad. Sciences, etc., France, vol. xxiv. No. 1, 1877; and Annales des Mines, sér. 8, Mémoires, vol. i. 1882, p. 161.

[6] Carruthers, Geol. Mag. 1870, p. 215.

Great advances have been made by Prof. Dr. W. C. Williamson in the knowledge of the lycopodiaceous trees of the coal, which he shows to have partaken of the exogenous structure of modern trees.

Various more or less artistic representations of ideal coal-forests are to be met with, both in special books treating of the subject and in treatises on geology in general. Eloquent descriptions of such a forest by Ansted and Hugh Miller are quoted by Balfour.[1]

Of the flora of the Uplands, which were bordered by the peaty coal-swamps, very little is known; only that the fern fronds and some other plants in the roof shales, and the occasional either prostrate or snag-like trunks of conifers in the sandstones, were probably brought to lower levels by streams or river-floods (Dawson, Lyell, and others).

II. The fossil animals of the coal are necessarily of very great interest, but we can now refer to only a few.

1. Of the invertebrates a fair number occur in South Wales, but none of the insects, myriopods, spiders, scorpions, eurypterids, land shells, and other rare forms known elsewhere have yet been met with.

In the "Memoirs of the Geological Survey of Great Britain," etc., Iron-Ores, etc., Part III., the late Mr. J. W. Salter very carefully classified and tabulated the fossils found in the 'ironstone bands' of South Wales, describing and figuring the most characteristic species. He hoped to have taken up the fossils of the coal bands in like manner, but unfortunately the time never came. His observations at p. 220, on the importance of managers of collieries and others making very careful collections of fossils, with notes on their exact beds, should even now command attention. He notes as follows:—

Black Band; Anthracomya, Fish remains	Brackish.
Soap Vein; Worm-burrows, Anthracomya, Ferns	Brackish.
Black Pins; Anthracosia, Dadoxylon, Knorria, and Halonia ...	Brackish.
Ell Balls, above Elled Coal; Asterophyllites, Lepidodendron, and Ulodendron, Ferns	Brackish.
Under Big-vein Coal; Anthracosia	Brackish.
Over Three-quarter Coal; Anthracomya	Brackish.
Will Shone, or Pin Will Shone, over the Bydyllog Coal; Athyris	Marine.
Darran Pins; Anthracosia, Anthracomya, Myalina	Brackish.
Over Engine Coal; Spirifer and Productus, Fern	Marine.
Black band, over Old Coal; Anthracosia, Fish	Brackish.
Spotted Vein; Spirorbis; track of Limulus (?) 6 feet below the vein	Brackish.
Red Vein; Anthracosia, Modiola, Edmondia (?)	Marine?
Blue or Big Vein: Myalina, Anthracosia, Spirorbis	Marine?
Bottom Veins; Fish (8 genera)	Brackish.
Rosser Veins; (under the Farewell Rock and above the Millstone Grit); Brachiopoda (7 genera), Conchifera (8 genera), Gasteropoda, Heteropoda, and Cephalopoda (9 genera), Encrinite Stems, Fish remains	Marine.

Anthracosia[2] was originally regarded as a *Unio* by Sowerby, then referred to *Cardinia* by Agassiz, and to *Pachyodon* by Stutchbury; but it was ultimately defined by W. King as related to *Unio*, but, being distinct from that genus, it was named by him *Anthracosia*. Mr. Salter noticed that it has a wrinkled epidermis, and considered that it was related to the *Myadæ*, and of brackish, if not marine, habitat. This is the shell composing the so-called 'mussel bands' and 'Unio bands' of the Coal-measures.

Anthracomya, 'Iron-ores,' etc., page 229. Mr. Salter indicates that the shells which he describes under this name have oscillated in catalogues between *Avicula*, *Modiola*, and *Unio*, and that it has a wrinkled epidermis, like the foregoing.

Anthracoptera[3] is a triangular shell, with wrinkled epidermis, and belonging to the same group as the above.

All the forms of this characteristic group of Coal-measure shells are called *Naiadites* by Dawson,[4] and regarded by him as allied to D'Orbigny's *Byssoanodonta*.

[1] "Palæont. Botany," pp. 70, 71. [2] *Iron-Ores South Wales*, pp. 226, 227.
[3] Salter, *Q.J.G.S.* vol. xix. 1863, p. 80. [4] *Acadian Geol.*, 1868, pp. 201–203.

Gümbel and Geinitz have described them as belonging to *Unio* and *Anodon*; and Ludwig refers *Anthracoptera* to *Dreissena*. At all events there is a great probability of their not being truly marine. They may have lived in the brackish water of lagoons and creeks in the black, muddy swamps, having some communication with the sea, and often or occasionally inundated with salt water (Dawson, Salter, etc.).

Spirorbis carbonarius is frequent in the Coal-measures of South Wales and elsewhere. This little annelid, though belonging to a marine genus, is often found attached to plant fragments in the coal-shales. These plants may have hung down into the water and been infested by the annelid; or it may have attached itself to floating plants which were ultimately drifted back to the littoral mud-swamp. This *Spirorbis* is an important constituent in the Ardwick limestone of Manchester and Shropshire, but is associated with Ostracoda (*Carbonia*), which are probably of brackish-water habitat.

The Brachiopoda are necessarily marine. The fish are not good witnesses, for they might have migrated to and fro, as some now inhabit both fresh and salt waters; and some might have been essentially estuarine.

Thus there are few decidedly marine beds in this series, and these, of course, correspond with the occasional domination of the sea during its inroads and during extreme depressions of the district.

In addition to the occurrences of fossils in Salter's list above quoted we may notice that in the Geol. Mag. 1870, pp. 214–220, is an account of some fossils discovered by the late Mr. W. Adams, of Cardiff, in 1869, in a 'Black Band' in the Rhymney Valley, about 800 feet higher in the Coal-measures of South Wales than any hitherto found. The band is calculated to have been rightly 81 feet above the Mynyddyslwyn coal, from which it is divided by a fault; it is in five layers and about 8 feet thick, with its associated shales. One of these in its midst and the lowest shale carry the fossils. With some plant remains there is *Anthracomya*, with *Estheria* (?) *Adamsii*, *E. tenella*, and *Leaia Leidyi*, all probably of brackish habitats; also *Carbonia Evelinæ* and *C. Agnes*, Ostracodes typical of a genus which is found in the black shales, presumably of either fresh or brackish-water origin. Mr. Adams also found a shale full of *Anthracomya* at Aberbeeg, Ebbw Vale, overlying the Troed-rhiw-Clawdd coal, and 226 yards below the Mynyddyslwyn coal (p. 215).

2. Of the Vertebrata the fishes enumerated in Mr. Salter's list are important. The following are the genera named:—Megalichthys, Rhizodus, Pleuracanthus, Byssacanthus (?), Palæoniscus, Amblypterus, Helodus, and Pœcilodus.

Although reptilian remains are rare in South Wales, yet they are not altogether wanting. In 1865[1] Professor (now Sir Richard) Owen described some remains of a small amphibian (between newt and lizard), found by the late J. E. Lee in the lower part of the Middle (or upper part of the Lower) Coal-measures at Llantrissant, Glamorganshire. The animal was rather larger than the allied *Dendrerpeton Acadianum*, and Professor Owen named it *Anthrakerpeton crassosteum*, "the thick-boned coal-reptile." This paper and its illustrations were reproduced in the "Trans. Cardiff Nat. Soc."

10. *Extent of the Coal-measures under the South of England.*—Sir H. De la Beche in 1846[2] noted that a great sheet of Palæozoic rocks, including the Coal-measures, extending from Belgium to Central England, had been rolled about, undulated, crumbled, and then partially worn away before the New Red Sandstone and other Mesozoic strata were laid down upon them; and that these, in their turn, had been denuded so as to expose here and there portions of the underlying Coal-measures, though near by a ridge of profitless Mountain-limestone or other older rock might come to the surface.

In 1856 Mr. Godwin-Austen, following up his reasoning about the areas of coal-growth (see above, page 521), explained that the movements of disturbance which they had undergone had tended to preserve the great Franco-Belgian coal-band, and had rendered it available; and he proceeded to state that the course of that band of Coal-measures may be traceable westward, and probably coincided with, and may some day be reached along the line of, the Valley of the Thames.

Professor Prestwich in 1871 extended this inquiry;[3] and, having carefully com-

[1] Geol. Mag. Vol. II. pp. 6, 8, Plates I. and II.

[2] *Mem. Geol. Surv.*, vol. i. pp. 213–214.

[3] *Report Royal Commission Coal-Supply*, 1871; *Anniv. Address Geol. Soc.*,

pared the coal-beds of Somerset and Belgium, described the characters and relations of the strata in detail, and showed that the coal might be met with at a workable distance from the surface along a narrow but interrupted curved area from Westphalia, through Belgium and France, to England; then along the north-eastern part of Kent (Isle of Thanet, etc.), and through Herts, Bucks, Oxfordshire, Gloucestershire, to the Bristol coal-field, and on to South Wales. The coincident axis of disturbance is south of the river Thames, in his opinion throwing off the coal-beds on its northern flank.

Mr. W. Galloway has given in the "Cardiff Nat. Soc. Report," vol. xvii. 1856, p. 23, a sketch of the views here alluded to. A full account of the history and literature of the question of the underground range of the older rocks in the South-east of England, especially as to the possible occurrence of the Coal-measures, is published in the "Memoirs of the Geological Survey: The Geology of London and of Part of the Thames Valley," vol. i. 1889, pp. 13-28, by Mr. Whitaker, F.R.S., who, having given close attention to this subject, has suggested the following localities as likely sites in the search for coal in the South-east of England: St. Margaret's, Chartham, Chatham, and Shoreham, all in Kent; Bushey (Herts), Loughton (Essex), and Coombs, near Stowmarket (Suffolk).[1]

An interesting fact relating to this matter is that in February, 1890, the engineer of a boring at the foot of Shakespear's Cliff, Dover, announced that at 1204 feet below the surface there a thin seam of coal was met with, and at several yards lower down coal eight feet thick was pierced, associated with clays, grits, and blackish shales (Newspapers). In Dr. Blanford's "Anniversary Address to the Geological Society" on February 21, 1890, he stated that Professor Boyd Dawkins, in a letter received the day before, had informed him that a coal-seam had really "been reached at a depth of 1180 feet, and that this seam is proved to be of Carboniferous age by the plant-fossils in the associated clays. . . . The discovery is solely the result of scientific induction, and arrived at by following the line of research first indicated, I believe, by the late Mr. Godwin-Austen, and subsequently by Professor Prestwich." The boring was undertaken with the advice of Professor W. Boyd Dawkins;[2] and we learn, from his latest Report,[3] that the Coal-measures were reached at 1113 feet below high-water mark, and were penetrated to 1500 feet; also that in the 387 feet of Coal-measures six seams were met with, giving an aggregate of 10 feet of coal. The distance of the Coal-measures below high-water mark is a near approximation to Professor Prestwich's computation of the probable depth at which coal might be found in that part of Kent, namely, 1000 to 1100 feet.[4] The account of the coal-plants or other fossils from these beds has not yet been published.

11. *Conclusion.*—The formation and subsequent arrangement of coal and the Coal-measures have been so ordered that the blessings of civilization have been largely enjoyed wherever the fossil fuel at man's feet has been industriously worked by his hands, and carefully applied to the improvement of his social being. These labours of careful perseverance, and arts of skilful manipulation, have given special characters to those whose energies have been directed to coal-mining and various manufacturing enterprises; and all conditions of society have been influenced thereby.

So also the geologist, chemist, and botanist, seeking out the composition of the various coals, their local position and extent, their special natural history, the mode of passage from dead plants to first-rate fuel—in fact, aiming at a complete mastery over all the mazy events and complicated results of the coal-formation—not only find a useful exercise of their cultivated intelligence and accumulated knowledge, benefiting all by the practical results, but they widen the mental culture of others, and show how the study of nature is an indispensable element in good education, and necessarily productive of lasting benefit to society at large.

1872; *Popular Science Review*, July, 1872; and *Proceed. Instit. Civil Engineers*, vol. xxxvii. 1874, p. 110, etc., plates viii. and ix.

[1] Geol. Mag. November, 1890.

[2] See also "Contemporary Review," April, 1890; and his "Lecture to the Royal Institution," June 6, 1890.

[3] "Report of Proceed. General Meeting of the South Eastern Railway Company," July 23, 1891, p. 10; and "Financial News," July 24, 1891.

[4] "Proceed. Instit. Civil Engineers," vol. xxxvii. 1874, pp. 16 and 26 of the separate paper.

Light, heat, motion, fragrance, and colour are all now obtainable from coal. What more could the sun himself do for us? It is as if the sunshine that cherished the luxuriant jungles of the past had been preserved in the coaly mass of the buried trees. Indeed, the light and heat of former days, expended in thus converting carbonic acid and water into coal, are here stored up for man. By converting coal into carbonic acid and water he can again evolve that heat and light, and use them in a thousand ways beneficial to his race—nay, essential to his very existence as a civilised being (J. W. Salter and others).

Nevertheless, a great deal has yet to be learnt about the natural history of the Coal-measures, the order and extent of the special kinds of their animals and plants, the time occupied in formation, and the geographical and hydrographical conditions. At all events, we know that all their strata have been arranged *in order*, have been buried under circumstances favourable to production of the various coaly fuels, and then turned up in *orderly disorder*, ready to the hand of man, and well adapted for his use in this passage-stage of his civilization and development, helping him, when intelligent, active, careful, and persevering, to higher ends. For we cannot doubt that all things here are arranged for his better being, his progress towards more and more useful arts, wider ranges of science, and fitter aptitudes of life, of which as yet we have but little conception. We are still the early settlers in a beautiful world, whose capabilities, imperfectly known as yet, wait until higher developments of man can understand them fully, and apply the results to the general good.

OBITUARY.

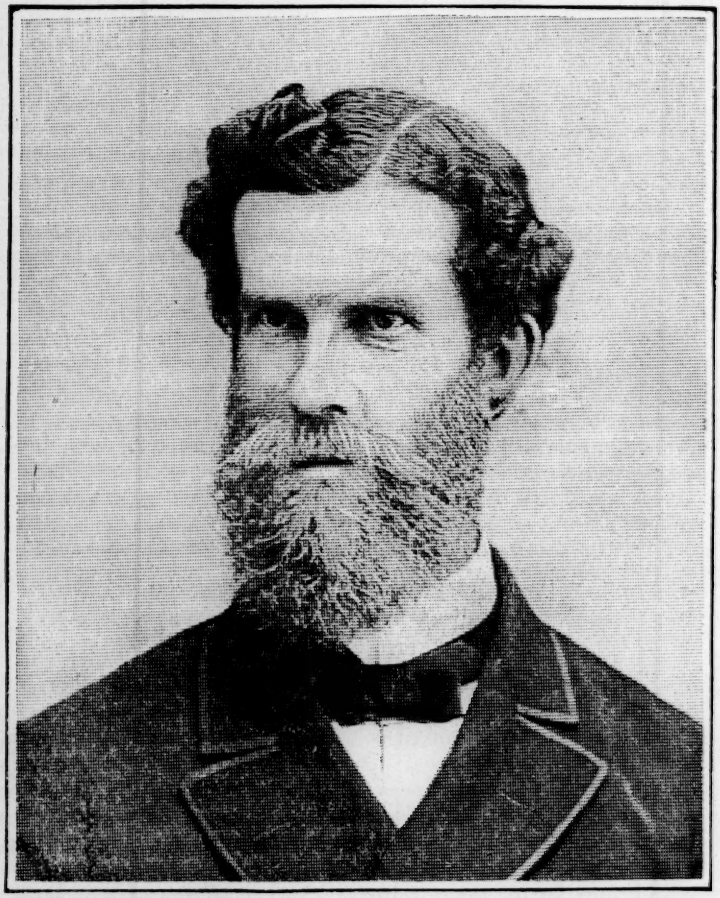
CHARLES SMITH WILKINSON, F.G.S., F.L.S., V.P.L.S.

NEW SOUTH WALES.

BORN 1843, DIED 23RD AUGUST, 1891.

Mr. WILKINSON was born in Northamptonshire. His father, Mr. David Wilkinson, was associated with George Stephenson in designing the first locomotive engines. His family settled in Melbourne in 1852, where he received his education. In 1859 he was appointed to the Geological Survey of Victoria under A. R. C. Selwyn, F.R.S., and in 1861 was employed in the Survey of the country from Bass's Straits northward to near Ballarat. Cape Otway mountains were surveyed by Mr. Wilkinson in 1863; and three years later, when engaged upon the Geological Survey of the Leigh's River District, some important investigations were made as to the mode of deposition of gold and the formation of gold-nuggets. Subsequently, Mr. Wilkinson's health gave way, and he spent three years in the Wagga district. In 1872 he passed the examination for licensed Surveyors in New South Wales, and was afterwards sent by the Surveyor-General to the then newly-discovered tin-mining district of New England, upon which he reported. He was appointed Geological Surveyor in the Department of Lands in 1874, and when, the following year, the Geological Survey was transferred to the Department of Mines, he was appointed Government Geologist for New South Wales, which office he filled until his death, with great ability and much advantage to the Colony.

Mr. Wilkinson was a member of the Board appointed to disburse the Parliamentary Vote for Government aid to mineral prospectors in his Colony. He has also served as President of the Royal Society of New South Wales and President of the Linnæan



Society of the Colony. His lengthened experience in practical geology and mining, and his scholarly attainments, united to a modest demeanour, gained for him a wide circle of friends both at home and in the Colonies. For seventeen years Mr. Wilkinson was a member of all Commissions for the Colony, in connexion with International and Inter-colonial Exhibitions, and he took a prominent part in preparing the collections showing the mineral resources of the Colony. He was also mainly responsible for the excellent collection of minerals in the Mining Museum at Sydney.

Mr. Wilkinson represented his Government as Geological Director of the New South Wales Royal Commission at the Mining Exhibition held at the Crystal Palace in the autumn of last year.

He was elected a Fellow of the Geological Society of London in 1876, and a Fellow of the Linnæan Society in 1881.

NOTE.—This Notice and the accompanying portrait of Mr. C. S. Wilkinson are reproduced, by the kind permission of the Editor, from the "Mining Journal" October 17, 1891.—EDIT. GEOL. MAG.

There may be many geologists in New South Wales ready to succeed Mr. Wilkinson in his post, but it will be difficult to find one possessing the same extensive geological and mineralogical knowledge, combined with so amiable a disposition and a readiness to impart information to those seeking it, which will cause his memory to be long held in esteem by all who had the pleasure to come in contact with him, whether officially or socially; and especially will his loss be deeply felt by a very wide circle of personal friends.

PHILIP HERBERT CARPENTER,

M.A., D.SC. (CAMB.). F.R.S., F.L.S.

Born February 6th, 1852. Died October 22nd, 1891.

Philip Herbert Carpenter, whose sad death we recorded in our last Number, was the fourth son of Dr. W. B. Carpenter, C.B., F.R.S. Born in Westminster, he was taught at University College School, and in 1871 went to Cambridge as a scholar of Trinity. In 1874 he graduated as B.A. in the first class of the Natural Science Tripos, and proceeded to the further degrees of M.A. in 1878 and D.Sc. in 1884. Between 1875 and 1877 he studied at Würzburg under Prof. Semper, and in the latter year was appointed assistant master at Eton College, being especially charged with the teaching of biology. This post he held until his death. In 1884, when his father received the Lyell Medal from the Geological Society of London, to Herbert Carpenter was awarded a moiety of the Fund. In 1885 he was elected a Fellow of the Royal Society, and he served on the Library Committee and Council of the Linnæan Society from 1887 onward.

By the death of Dr. Carpenter, at the early age of thirty-nine, we lose one of the chief authorities on Echinoderm morphology and the acknowledged leader in the study of the Crinoidea. For this position he was by his early training eminently fitted. As a boy his interest was excited by the researches which his father was prosecuting into the embryology and morphology of *Antedon*. When only sixteen he joined his father and Wyville Thomson on the deep-sea exploring expedition of H.M.S. *Lightning*, "manfully bearing no little hardship and helping to lighten the evil times to his seniors." It is interesting to remember that the chief incentive to that exploration was the discovery by Sars of new Crinoids in the North Sea two years before. In 1869 he was on the second and third cruises of the *Porcupine*, making analyses of sea-water, but no doubt keeping an eye on the many rare animals, especially Echinoderms, dredged by that vessel. The summer of 1870 was again spent on the *Porcupine*, this time in the Mediterranean. In 1875 he accompanied Sir G. Nares' Arctic Expedition as far as Disco Island, for the purpose of assisting in the dredging operations that were carried out there and in the North Atlantic by H.M.S. *Valorous*.

It was not, however, till September, 1875, that he turned his attention seriously to the Crinoidea, and then as it were by chance. His first studies at Würzburg were on "the minute anatomy of the genital glands in the Crayfish." It happened, however, that Semper and Ludwig had criticized certain statements of W. B. Carpenter

with regard to the arms of *Antedon*, and P. H. Carpenter naturally wished to examine Semper's material. Thus his first paper (Journ. Anat. and Physiol.) reconciled the views of his father and of his father's critics. The interest once aroused led him on to the investigation of the Phillipine *Actinometræ*, placed in his hands by Semper, and after two years' work he presented to the Linnæan Society the important paper on that genus which is published in their Transactions. Meanwhile the *Challenger* expedition had returned, and in January, 1878, the description of the free-swimming Crinoids collected on it was entrusted to Carpenter by Sir Wyville Thomson. Thus his scientific career was determined, and from that time to his death, a constant stream of papers from his pen, on Echinoderm and especially Crinoid morphology, found their way to the Royal, Linnæan, Geological, and Zoological Societies of London; to the Quarterly Journal of Microscopical Science, the Annals and Magazine of Natural History, Zoologischer Anzeiger, and many other publications.

The report on the *Challenger* collection of Stalked Crinoids was to have been written by Wyville Thomson, but on his death in March, 1882, the work naturally fell to Carpenter. This report, published in 1884, and that on the unstalked forms, which appeared four years later, embody the main work of Carpenter's life: their accuracy and exhaustiveness are known to all who have to deal with Crinoids. This led to much other systematic work, such as that on the *Comatulæ* of the Leyden Museum, of the Hamburg Museum, of the Barent's and Kara seas, and of the Mergui Archipelago; besides much left unfinished on the Blake collections from the Carribbean sea, the Crinoids from the Port Philip Survey, from Torres Straits and elsewhere.

What must strike any one who reads these reports is the constant allusion to fossil forms. The refusal to separate for a moment the animals preserved to us in the rocks from those living in modern seas, which distinguished Carpenter's work from that of most zoologists, constitutes his chief claim on the attention of the readers of this MAGAZINE. "I have," he said "the strongest conviction (and many mistakes would be avoided were it a universal one) that the only way to understand fossils properly is to gain a thorough knowledge of the morphology of their living representatives. These, on the other hand, seem to me incompletely known if no account is taken of the life-forms which have preceded them." And this conviction was acted up to: thus, even a new *Antedon* from the Mergui Archipelago was shown by him to throw light on the position of Jurassic species. No stronger argument than the extreme value of all Carpenter's palæontological papers can be needed to show the utter fatuity of ever expecting really good work to be done upon fossils by those who are prohibited from acquiring a practical knowledge of their living relations. For those, however, less fortunate than himself his help was always ready, and none will feel his loss sooner or more bitterly than they who have so often availed themselves of it in solving the many problems presented by the Crinoids

of the past. Besides many papers contributed to the Geological Society, Carpenter was joint author with Mr. R. Etheridge, jun., of the Catalogue of the Blastoidea in the British Museum; and the last number of the Journal of the Linnæan Society, published on the day of his funeral, contains a contribution to the Morphology of the Cystidea of the very highest importance (see *antea*, p. 135).

Carpenter's enthusiasm made him a keen controversialist, but his love of truth kept him open to every argument. He may have sacrificed brevity to exhaustiveness, but his conscientiousness has given to all his work the highest reputation for accuracy. These are the virtues of the man of science, but to them he added a kindness of heart and a bright joyousness of nature that leave us doubtful whether we have lost more in the teacher or in the friend.

Lists of Dr. P. H. Carpenter's papers, some written in conjunction with Mr. R. Etheridge, jun., are given in his two *Challenger* Reports, and in the Catalogue of the Blastoidea in the British Museum. To these the following list is supplementary.

1882. On the Relations of *Hybocrinus*, *Baerocrinus*, and *Hybocystites*, Quart. Journ. Geol. Soc. vol. xxxviii. (No. 151), pp. 298–312, pl. xi.
1886. Note on the Structure of *Crotalocrinus*, Ann. Mag. Nat. Hist. ser. 5, vol. xviii. pp. 397–406.
1887. Notes on Echinoderm Morphology, No. 11; on the Development of the Apical Plates in *Amphiura squamata*, Quart. Journ. Micr. Sci. vol. xxviii. pp. 303–317.
1889. Report on the Comatulæ of the Mergui Archipelago, etc., Journ. Linn. Soc. London (Zool.), vol. xxi. pp. 304–316, pls. xxvi. and xxvii.
1890. Preliminary Report on the Crinoidea obtained in the Port Phillip Biological Survey, Proc. Roy. Soc. Victoria, new series, vol. ii. pp. 135–136.
1890. On certain points in the Anatomical Nomenclature of Echinoderms, Ann. Mag. Nat. Hist. ser. 6, vol. vi. pp. 1–23.
1891. Some publications on American Carboniferous Echinoderms, Ann. Mag. Nat. Hist. ser. 6, vol. viii. pp. 94–100.
1891. On certain points in the Morphology of the Cystidea, Journ. Linn. Soc. London (Zool.), vol. xxiv. pp. 1–52, pl. i. Abstract in Rep. Brit. Assoc. for 1890, p. 821; and in Geol. Mag. Dec. III. Vol. VIII. p. 135, March, 1891.
1891. Notes on some Arctic Comatulæ, Journ. Linn. Soc. London (Zool.), vol. xxiv. pp. 53–63, pl. ii.
1891. Notes on some Crinoids from the Neighbourhood of Madeira, *op. et tom. cit.* pp. 64–69.

Dr. Carpenter also contributed an admirable popular account of the Echinoderms to Cassell's Natural History (1883), and was largely responsible for the section on the same group in Nicholson and Lydekker's Palæontology (1889). F. A. B.

Henry Nottidge Moseley, LL.D., F.R.S., who, after a protracted illness, died on the 10th of November last, at the age of 46, was well known as a "Challenger" Naturalist, and as Linacre Professor of Comparative Anatomy at Oxford. That part of his published work of most interest to the palæontologist related to the Hydrocorallinæ, Alcyonaria and Madreporaria. But throughout his work, especially in his capacity as teacher, he was always alive to the value of fossils, and lost no opportunity of impressing on his pupils the importance

of their study. His enthusiasm, his energy, his genial humour and his far-travelled experience would often keep the attention of his youthful hearers for a full hour beyond the appointed lecture-time; and, though his voice has for some years been silent, his memory will not yet cease to be dear to all who had the privilege of knowing him.

Thomas Pallister Barkas, F.G.S., was stricken with paralysis about a month prior to his death, which we regret to record occurred on the 13th of July last. He was born in Newcastle on the 5th of March, 1819, and in his early days was a well-known lecturer in his native city on scientific and literary subjects. To geologists he is best known by his "Coal-measure Palæontology" (1873), illustrative of the fauna of the Northumberland Coal Field. In this book he figured numerous specimens preserved in his own collection, and others which he had given to the local museums. Mr. Barkas was a great populariser of his favourite science, and took a warm interest in the Newcastle-on-Tyne Natural History Museum.

CORRESPONDENCE.

CONCERNING NOMENCLATURE.

Sir,—In reading Mr. J. W. Gregory's Revision of the British Tertiary Echinoidea in the "Proceedings of the Geologists' Association," vol. i. parts 1 and 2. 1891, I was, of course, impressed with the industry and acumen of the author, but I was much grieved at finding that ten of the original specific names given by Professor Edward Forbes in 1852 are maltreated by arbitrary and unnecessary alteration, after the latest fashion of pseudo-classical nomenclaturists, who propose to bring specific names to one artificial form and standard. They forget that the original "*Woodii*," for instance, is preferable to *Woodi*, being more euphonious,—and that a name may be as lawfully latinized after the plan of *Junius* as of *Iulus*; and that there are as many Roman names ending in *ius* as in *us*. Further it seems to be forgotten, or not known, that the genitive in a specific proper name indicates the author's intention of honouring the discoverer of the specimen, whereas the adjectival form, as *Branderianus*, has reference to one otherwise connected with the species. Thus, to change "*Hemiaster Branderianus*" to *H. Branderi* is to falsify, not only the fact in nomenclature, but the author's intention to indicate the method and degree in which he meant to honour the person named. The reduction of capitals in specific names, as in *branderi*, is unworthy of real literateurs, convenient to printers, if any of them wish to save a little arm-stretching in composing the type,—and depriving both beginners and experts of seeing at a glance some indication of the scientific history of the species. Linné's method of giving initial capital to any noun used as a specific name is far preferable to the new fashion, which is probably based on the unimportant circumstance that in ancient inscriptions only uncial and uniform letters were used.

T. Rupert Jones.

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